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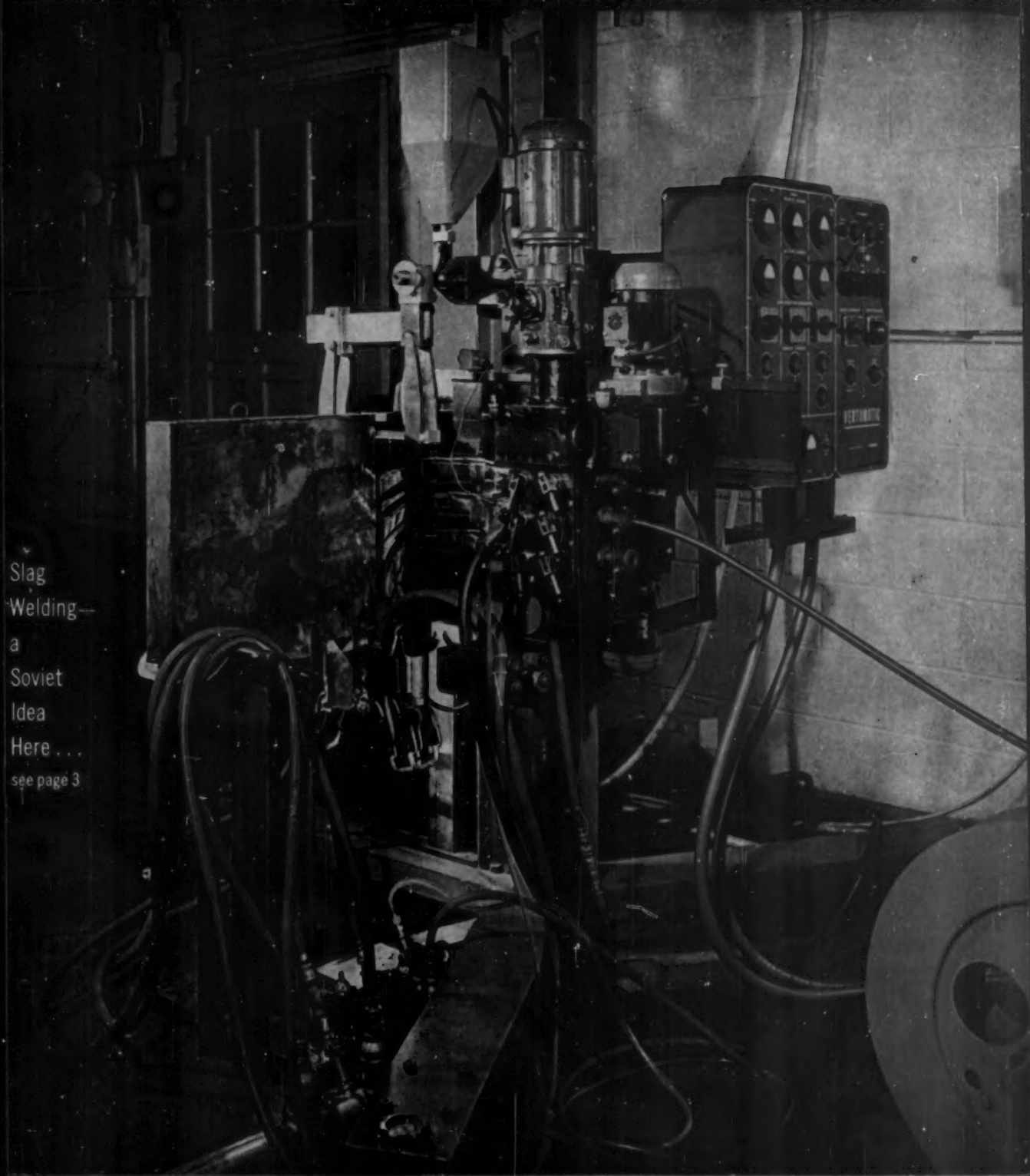
PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT · FEBRUARY 8, 1960



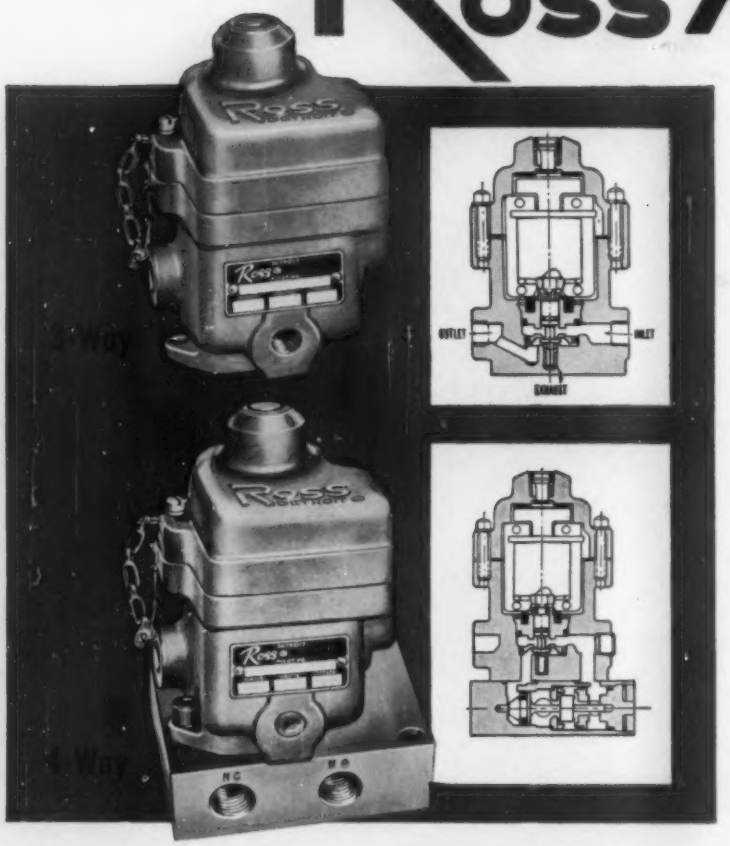
Slag Welding—a Soviet Idea Here . . .

see page 3

Announcing

a new and better solenoid valve in the $\frac{1}{8}$" and $\frac{1}{4}$" size range

Ross PACER



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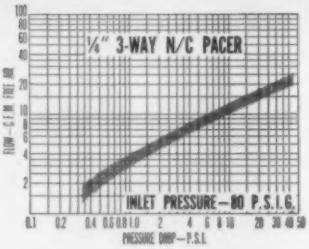
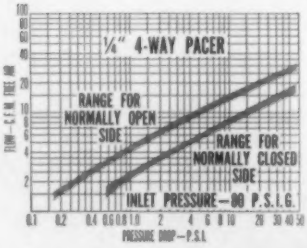
Pressure drop thru 3-way N.C. Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shown as a range rather than as absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



Pressure drop thru both N.C. & N.O. sides of 4-way Pacer valve under steady flow conditions. Inlet pressure 80 psig. Data shows ranges for each side rather than absolute values due to variables such as barometric pressure, manufacturing tolerances, etc.



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PRODUCT ENGINEERING

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

February 8, 1960 Vol. 31, No. 6

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A Tiny Producer, the honeybee, is equally famous as a supplier of a favorite delicacy and as a pollinator of valued crops. Worker bees — the only nectar-gatherers, honey-processors and home-builders — are always the smallest members of their colony. About ½" long, they're considerably smaller than drones.

Small Pain-Reducer. In this newest dental handpiece, tiny MPB bearings permit the head to be miniaturized for easier use and better visibility, particularly with children. The MPB bearings used here must withstand punishing acceleration from 0 to 250,000 rpm in a half-second, the speed necessary for comfortable, quiet drilling.

Man With Miracles. Every day MPB Sales Engineer Ray Armstrong helps industrial and scientific engineering staffs to select miniature bearings that reduce friction and increase accuracy of instruments and other devices. An MPB sales engineer is always ready to help you develop the miniaturization your products need.

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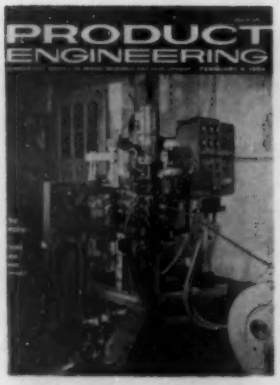
INTERESTING TO NOTE

Electroslag—Child of the Arc Lamp



During World War I some interned German ships became guinea pigs for a group of metalworkers who wanted to test a new way to weld ruptured cylinders. The method was called "arc-welding" because its heating elements were rods similar to those in a carbon arc lamp. A Russian, N. V. Bernardos, patented the process in 1887, soon after the principle of the carbon arc light was developed. Arc welding was soon improved first by another Russian, Nicholas Slavianoff, and then by an American, C. L. Coffin.

In 1908, Bernardos received another patent, for arc-welding plates in an upright position. Graphite molds were pressed against the face of the plates on each side of the joint to hold the molten weld in place. Another Soviet engineer, G. S. Voloskevitch, combined the Bernardos vertical-welding concept with the principle of heating by slag resistance. Here, resistance to current flow in the molten slag provides the heat to melt the weld metal. According to Soviet literature, vertical welding has been practiced in the USSR since 1951. Since then, most development has aimed at improved instrumentation. In this field, the Bratislava Institute of Welding in Czechoslovakia has developed controls that now are incorporated in the Arcos electroslag welding equipment pictured on our cover and described on page 52. This equipment is now available in the US.

From Thermometer to Fibers

Prior to 1897, thermometers had to be hand-made—there was no way to draw glass mechanically. Then two technicians at the Corning Glass Works, Arthur A. Houghton and Charles E. Githler, found an answer. They built a square wooden tower containing a cable and pulley. Attached to the cable was a blow-pipe, tipped with a specially shaped ball of hot glass. The glass was anchored to the bottom of the tower. When the cable was pulled, the blowing iron started upward, drawing the glass into tubing.

This success spurred scientists to investigate further a problem that had hounded glassmakers since the 1850s—forming glass fibers. During the early 1900s, glass men at both Corning and Owens-Illinois studied the problem. O-I's first laboratory demonstration of the principle of producing fiberglass consisted of feeding glass rod into the flame of an oxyacetylene burner. Combustion gases of the specially designed burner drew out the resulting molten filaments of glass. When a wire screen was placed a short distance in front of this blast, it quickly became coated with a mat of fine fibers. In 1938, the two companies exchanged patent licenses and formed the Owens-Corning Fiberglas Co. On page 41 is a discussion of fiberglass as a sprayed plastic reinforcement.

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Even Candles Needed Standards

Candles that didn't fit into candle-holders annoyed householders of old. There was no standard size for candles, so most of them had to be whittled before they would fit in a holder. Joseph Whitworth (later, Sir Joseph) was probably the first British engineer to preach standardization as a means of obtaining interchangeability. He illustrated his point by stressing the need of a standard-size candlebutt and candlestick.

Whitworth later developed a system of standard gages that was adopted by British industry. In 1841, he read a paper before the Institution of Civil Engineers, urging the adoption in Britain of a uniform system of screw threads in place of the various different pitches and dimensions then used. More than a century passed. The American Standards Association tells us that in 1948, after over thirty years of negotiation, America, Britain and Canada agreed to merge the Whitworth Thread and the American Standard Thread into a Unified System of Screw Threads.

Before this agreement every manufacturer of screw threads made its own standard. This was tragically demontrated in Baltimore on February 7, 1904. A fire broke out in the city's old business section. Local fire departments rushed to the scene but the fire spread faster than they could control it. Pleas for help went to Washington, Philadelphia and New York, and special trains rushed equipment to Baltimore on cleared tracks. However, all the out-of-town fire-fighting apparatus stood idly by while 150 acres valued at several million dollars burned to the ground—the other hose couplings would not fit the Baltimore hydrants. Twenty-three years later, fire-fighting equipment from 20 towns saved Fall River, Mass from total destruction. This time, hydrant and hose connections had been standardized.

The ASA is the American association concerned primarily with standards; however, there are a great many other societies and associations in this country that publish standards independent of the ASA. To help the engineer keep abreast of trade associations and societies that publish standards as well as other data of interest to the designer, see the special report on page 55.

—Benedict A Leerburger Jr

SIDELIGHTS

Furthering our collection of design definitions (*June 15 '59, p 4*) here are some elucidations of descriptive literature for your reference file.

New—different paint job
All new—parts not interchangeable with old design
Exclusive—just copied from Europe
Unmatched—almost as good as competition
Design simplicity—costs cut to the bone
Stylized design—standard parts
Advanced design—ad writer couldn't understand it
Field tested—the lab was too crowded
High accuracy—the joints meet
Rugged—too heavy to be lifted by ad writer
Durable—won't quite last the guarantee
Heavy-duty—will last the guarantee
Trouble-free—only the repairs cost money
Finest—slightly higher in price

NEXT WEEK IN PRODUCT ENGINEERING

. . . Wet-cell Batteries for Power
When you need an independent power source, check this article for 5 rechargeable types.

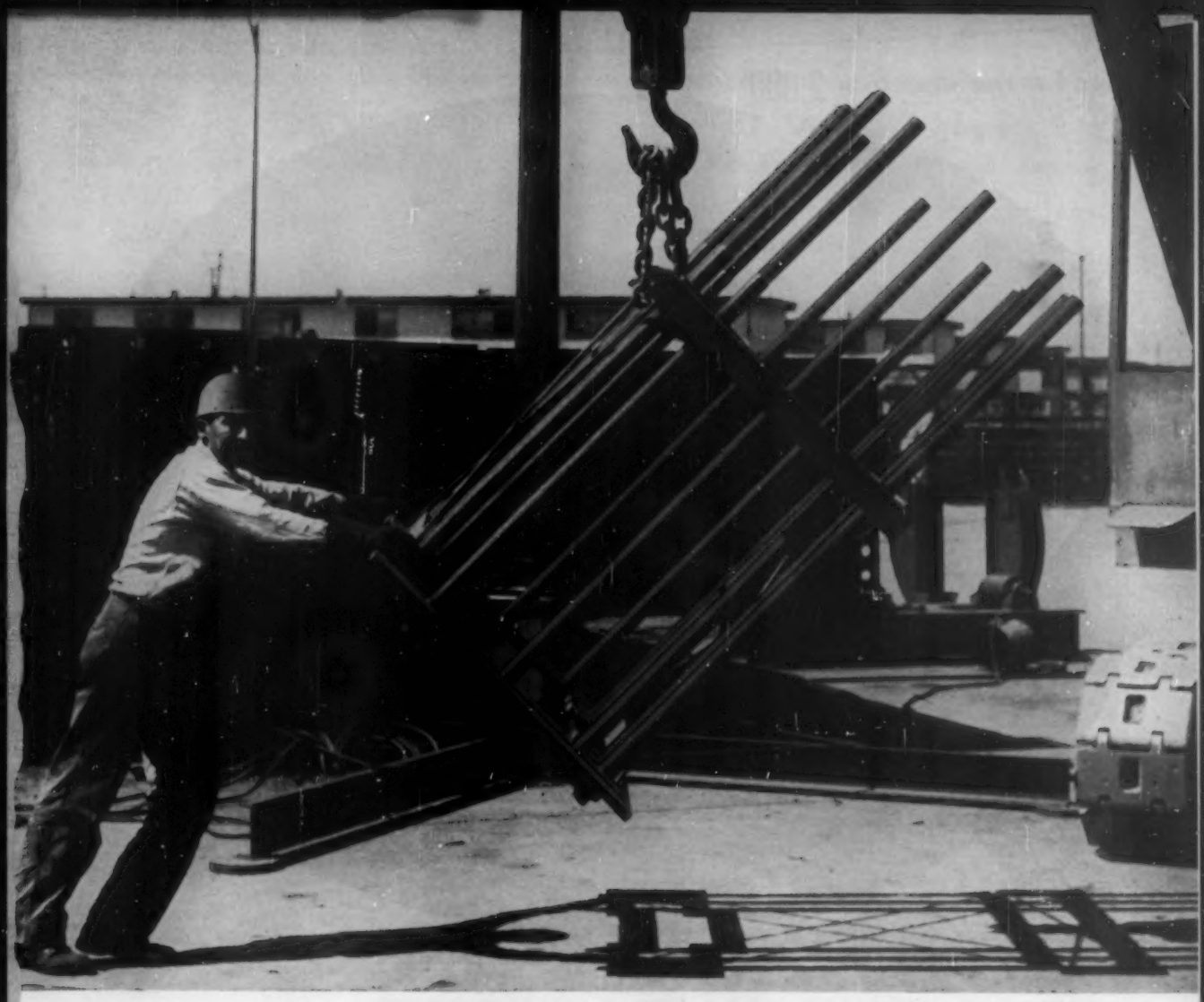
. . . 5 Ways to Select Change Gears
Included is the faster automatic-calculator method that needs less trial and error, less manual computation and gives a faster answer.

. . . 3 Shortcuts for Comparing Test Results
For experiments, as well as quality control and reliability studies, these charts give quick answers.

. . . Natural Frequencies of Honeycomb Structures
Vibration charts of honeycomb panels compared with steel panels.

. . . 9 Cures for Badly Riveted Joints
How to recognize and prevent faulty work.

. . . Cryogenic Sizing Freezes Accuracy into Stainless Parts
Down at —100 F this process offers close tolerances at low cost for complex parts.

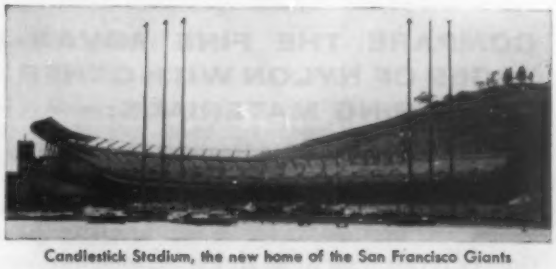


Big bolts for the Giants' ball park

Threaded foundation bolts, two inches in diameter and eight feet long, 14 of them in all, were welded into this mammoth cage. This section will be embedded in concrete as an anchor for one of several steel shafts supporting the lighting system for the San Francisco Giants' new Candlestick Stadium.

The range of Bethlehem standard fasteners is wide enough to handle most bolting requirements. But quite often a special job, such as this one, calls for a special fastener designed to meet the specific need.

We can make an almost unlimited variety of special fasteners. Just send us a pencil sketch or drawing. Our fastener engineers will study it; and perhaps they can recommend changes that will save you money. We're equipped to give you prompt action. For full details, get in touch with our nearest sales office.



Candlestick Stadium, the new home of the San Francisco Giants

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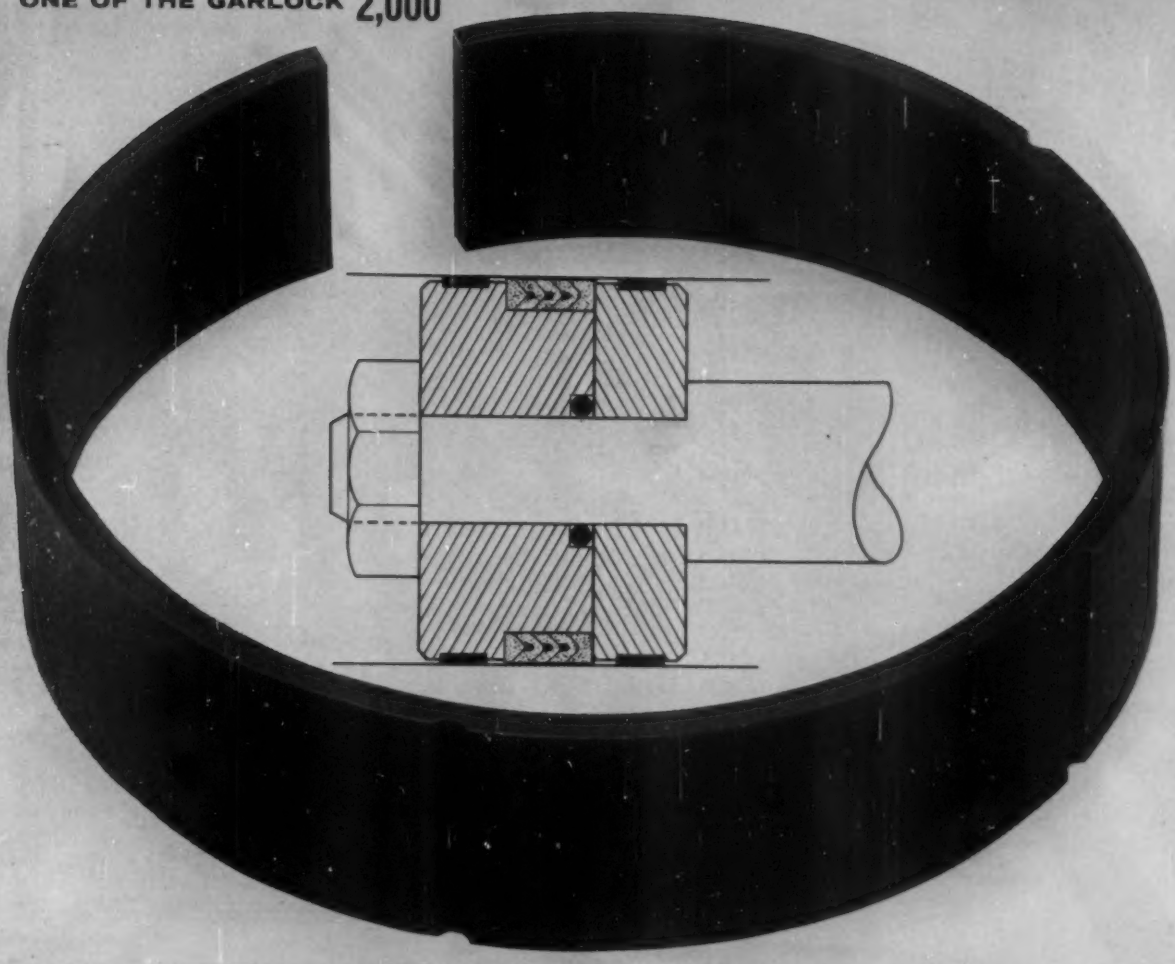

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DEVELOPMENTS TO WATCH . . .

British design induction motor with continuously variable speed

A sliding-rotor device in which the poles change gradually over the entire length of the stator, has been built at the U of St Andrews in Scotland. It might, its developer says, be described as a "pole-changing machine."

The stator is a stack (about 100) of ring stampings with varying numbers of slots—the first stamping has 36 slots, 10° apart; the last has 40 slots, 9½° apart. The slots therefore form a rudimentary series of helixes, each with a different pitch.

The sliding rotor may be either solid or squirrel-cage; and is so arranged that rotor speed varies from a maximum when it is close to one end of the stator to a minimum when it nears the other end. The variation is on the order of 10%—450 rpm to 500 rpm, for example.

In the prototype model, the rotor is 9 in. dia and 1 in. thick; airgap is 15 mils; the stator is 13 in. dia and 2½ in. long.

As its developers emphasize, this is purely a prototype, designed to demonstrate the principle and explore speed/torque characteristics. The mmf is supplied by a heavy current flowing in a single turn of wire, and no attempt has been made to reduce stator losses. For this reason, efficiency cannot be estimated—but it's believed that "reasonable efficiencies are to be expected of a less primitive model."

More multilayered coatings for ultrahigh temperature service

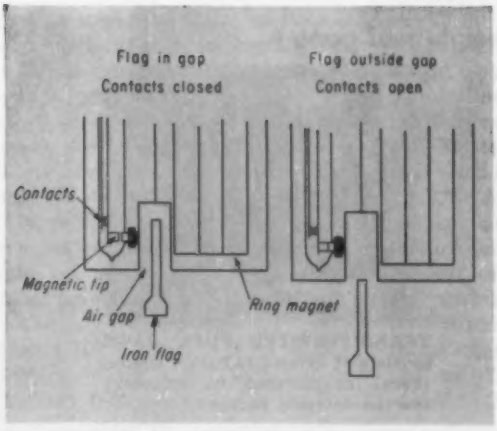
New combination coatings that stand 4000 F and more are making their debut, as designers and engineers strive to meet stringent demands of the jet and nuclear age.

Already under test for missile applications are such combinations as chemical-ceramic-metal coatings on a steel or titanium base (*PE*—Nov 16 '59, p 15). Now, aircraft and nuclear engineers are exploring similar possibilities for protection of graphite.

Under test at Chance Vought Aircraft, for instance, are refractory metal-oxide coatings that show promise for protection of both graphite and metals at temperatures to 4500 F for short periods at least, and to 3500 F for periods as long as 40 min. Most promising, says W. L. Aves Jr of Chance Vought, are multilayed molybdenum-alumina coatings, using 3 to 5 layers of each material (each 0.002 to 0.005 in. thick for a total coating thickness of about 0.028).

In a preliminary report on this work to the last Electrochemical Society meeting, Aves emphasized that no one coating is likely to prove satisfactory for every environmental condition—even at a specified temperature, and it's likely that special combinations will have to be developed for each type of application. Research is needed, too, to develop coatings for service at even higher temperatures (to 5600 F) for very short periods, and for 4000 F for extended operation.

Vacuum-sealed switch operates by remote control



A switch, with its contacts vacuum-sealed in a glass envelope, and operated by manipulation of its magnetic field is being introduced by Franz Baumgartner, Niehl 3, Cologne, W Germany for use under dusty, corrosive, or explosive conditions.

The design itself is extremely simple. It consists of an envelope containing the contacts, a ring magnet, and an iron "flag" (much like the flag on a rural mailbox) which can move into and out of the space between the magnet and the envelope. When the flag is "down" (outside the gap), the force of the ring magnet, acting on a magnetic tip on the movable contact, pulls the switch to the "off" condition. When the flag moves up into the gap, it shunts the permanent-magnet field, releasing the movable contact —and the switch is "on."

IRON FLAG TURNS SWITCH ON as it moves into gap between ring magnet and contact envelope. As an indication of size, gap is about ½ in. wide.

Big steel promises tin plate—lighter, stronger, cheaper

Girding to meet the challenge of aluminum, paper, and plastic laminates, the steel industry is getting down to business on a number of new developments, among them new enameling steels and a vastly improved tin plate. Says Roger Blough of US Steel:

"We are now working on a new tin plate which—if it proves to be as promising as now appears—will be lighter, thinner, and stronger than any tin plate now available."

New route to ductile tungsten?

A new form of high-purity tungsten that can be hacksawed, and hammer-forged at temperatures as low as 1650 F, has been uncovered by Bureau of Mines researchers at Albany, Oregon. It's the result of work on tungsten "bomb" reduction methods, in which calcium metal is allowed to react with tungstic oxide in a sealed container. Researchers found that tungsten produced this way differs markedly in its properties from high-purity tungsten refined by vacuum melting and other methods. As yet, the material has not been fully tested; but reductions in thickness of about 70% have been achieved by hammer-forging iron-sheathed ingots.

Machinable carbides to be offered for structural use

Carbides that offer a good combination of oxidation resistance, hot-hardness, and wear resistance are now in pilot production at Sintercast Div, Chromalloy Corp, Yonkers, NY; and the company expects them to find a variety of structural applications.

These are titanium carbides bonded with stainless steel. One, containing 39% TiC, 11% Cr, and 7.3% Ni, has a Rockwell hardness of 45 C. The other, with 52% TiC, has a hardness of 55 C. Both materials are said to retain their hardness and resist oxidation at temperatures at least to 1250 F; to show a tensile strength on the order of 270,000 psi; and to be machinable by milling, drilling, or sawing. Cost—on a volume basis—is expected to be comparable with that of tungsten carbide.

Are we losing our lead in basic metals?

Soviet metals production is rivaling that of the US, latest National Industrial Conference Board figures indicate. Already, the USSR has passed the US in coal and iron ore output (*PE—Dec 2 '57, p 17*). Now it's coming pretty close on steel. In aluminum and copper, though, the USSR still has a long way to go.

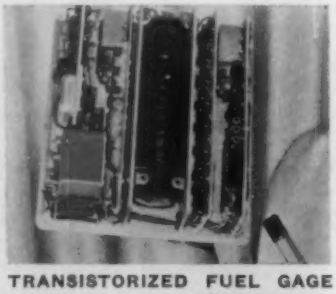
According to the latest NICB figures, the USSR produces 22% of the world's iron ore, 20% of the coal (US: 17% and 16% respectively). In steel, it's 29% for the US: 20% for the USSR. In aluminum and copper, the percentages are: US, 40% and 27%; USSR, 16% and 12%.

Five years ago the USSR was turning out less than half as much steel as the US, less than a third as much aluminum, and about a third of the copper.

Activated atoms and transistors combined in lightweight fuel gage

A fuel gage "more accurate and reliable than conventional devices" is being developed for the Navy by Atomics International, using a radiation source and detector as the monitoring system. Like other radioactive gages, it determines liquid level by measuring the amount of radiation which gets through the liquid containers—less radiation being received by the detector when the probe is below the surface of the liquid than when it is above. The new device, however, is able to compensate for changes in fuel composition, and is not affected by impurities in the fuel; so "all types of solid and liquid propellants can be measured."

—ARG



TRANSISTORIZED FUEL GAGE consists of gamma radiation source (here incorporated in cylinder) and the detector package.

WHAT'S HAPPENING IN RESEARCH . . .

Looking over the atom horizon

Element 105—when we find it—will be a lot like tantalum and columbium, predicts Glenn T. Seaborg, Chancellor of the U of California. It may be a long time, if ever, though, before we have enough of it to make sure.

As one goes up the atomic scale beyond uranium (number 92), the elements become less and less stable. There is little hope of finding a long-lived one in the upper reaches—one that will not break down or decay into smaller atoms in short order.

Still, scientists today need only a very tiny amount of a new element to learn a great deal; and they are by no means abandoning hope. Element 102, for instance, has been identified though its half-life is only 3 sec and only a very few atoms of this type have ever been made.

This element, tentatively named nobelium, is the highest produced so far (see chart). The next goal, naturally, is number 103. However, because of the methods used to produce new elements, it is entirely possible that the next one made will be 104, 105, or even 107. This is because new elements are created by bombarding the elements we have with nuclear particles. If the particle used is hydrogen, with a single proton, then the new element that is created is likely to be just one step above the old. But hydrogen is not necessarily the best "projectile." Today, scientists are working with nuclear "bullets" that have 6, 7, and 8 protons (the nuclei of carbon, nitrogen, and oxygen), so it may be easier to make a higher element than number 103.

Actually, as Seaborg pointed out to a press conference at the time he received the AEC's Enrico Fermi award, we have played this kind of atomic leap-frog before. Curium, element 96, was made—by bombarding plutonium, 94, with two-proton helium nuclei—before element 95, americum, was created. The latter was produced later, from neptunium (93).

The scientists would not mind missing 103 for a while if they could produce 104 or 105. The reason is that 103 falls within, and is the last of, the actinide series of elements that starts with element 89 and closely parallels the rare-earth series, 58-71. (Element 89 itself falls out of the main line of this group; but, is generally included with it, as yttrium, number 39, is classed with the rare earths though it falls outside the rare-earth group.)

Thus, element 103, last of the "heavy rare earths," is expected to resemble lutetium, number 71, last of the rare-earth group. Element 104 will fall back in the main stream of the periodic table—under hafnium; numer 105 will be in the tantalum group; and number 106 should be a tungsten-like material.

The elements beyond uranium

Here's a rundown—number, name, and symbol—of the elements made to date. None of these has been found in nature.

93	Neptunium	Np
94	Plutonium	Pu
95	Americum	Am
96	Curium	Cm
97	Berkelium	Bk
98	Californium	Cf
99	Einsteinium	E
100	Fermium	Fm
101	Mendelevium	Mv
102	(Nobelium)	(No)

Instruments can be kept cool in space

Temperatures can be controlled within reasonable limits in outer space, recent reports on Explorer VII indicate.

Design requirements were −32 to 140 F; but, most of the time, the instruments were held close to 64 F.

The "passive" thermal protection for the instrument package—gold foil plus highly polished metal surfaces, to reflect heat—managed to maintain temperatures between 61 and 106 F, even during a 5-day period of 100% sunlight.

The satellite itself has a glass fiber shell, painted on the inside with a titanium coating that has high infrared passivity. Heat can be, and is, transferred from one half of the shell to the other by radiation to equalize hot and cold sides. Gerhard Heller of ABMA says this form of heat transfer is remarkably efficient. Tests showed, he said, that equivalent performance could not be obtained even with very heavy copper heat-conducting bars.

Tips on bright tin coatings

Anode composition is the key to bright tin-copper plating on steel, Tin Research Institute reports. Bronze anodes with 0.2 to 0.4% lead will produce deposits that are not brittle and "retain their brightness up to a thickness of 0.003 to 0.004 in." With higher lead content, brittleness occurs at lower thicknesses; and with lower lead content, the brightness is not satisfactory.

The importance of lead content is emphasized by the fact that the only other commercial method for producing coatings of this type reported by TRI involves adding lead to the electrolyte.

Briefs . . .

Indium-mercury alloys that show sharp transition points to the superconductive state at ultralow temperatures are under study at IBM research laboratories.

Materials like these, which lose all their resistance as they approach absolute zero, yet can be "reconverted" by application of a magnetic field, show great promise as computer "memories," on-off switches and other electric components.

At the American Physical Society Annual meeting, the IBM researchers reported tests of In-Hg alloys containing 0.7% Hg. Surprisingly, the transition temperature decreased with increasing amounts of Hg up to 1.75%; but increased as more Hg was added.

New thermonuclear center to employ 1000 people is being blueprinted in Britain. It will house one of the largest plasma machines (*PE—Nov 4 '57, p 12*), and centralize all British research on nuclear fission. The site: Culham, Oxfordshire. UKACA is now selecting the necessary authorizations. —ARG

FIRST in strain measurement

SR-4 BALDWIN BLH LIMA-HAMILTON

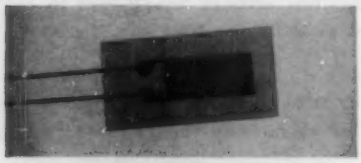
STRAIN MEASUREMENT

DATA SHEET No. 2

HOW TO MATCH THE STRAIN GAGE TO THE JOB

If your business is mechanical design, development or testing, chances are good that you have used, or will some day use, SR-4® Bonded-Filament Strain Gages. Unique in their simplicity, versatility and accuracy, they are the natural answer to a great many problems involving the behavior of materials, components and structures under load.

When the need arises, however, many engineers without specific background in strain-gage techniques find themselves on unfamiliar ground in attempting to select the best gage for the job from over 250 available types. Although it is important to the validity of the results that the gage used be properly suited to the application, selection is normally not a difficult matter and depends principally on known test conditions and on the nature of the data required. When the following criteria have been established, a suitable gage type for a specific application may be readily selected from the SR-4® Catalog.



Bonded foil gage

1. Temperature—The temperature at which the test is to be conducted is an important (frequently limiting) factor in determining suitable grid and base materials. At room and moderately high temperatures, both wire and foil gages are used. At temperatures above 350°F (and at very low temperatures), foil gages must be used. Some types are available with a backing material which may be stripped off during application, the grid alone being bonded to the test area. Such gages may be used up to 1400°F (for dynamic-type tests).

SELECTION OF GAGE MATERIALS BASED ON TEMPERATURE

Maximum Temperature (°F)	Base Material		Filament Material
180	Paper, Bakelite, Epoxy		Any
250	Bakelite, Epoxy		Any
350	Bakelite		Any
600	None	Strippable backing	Constantan or Nichrome foil
1000*	None		Nichrome foil
1400* (dynamic only)	None		Nichrome foil

*Limit imposed by available bonding adhesives

2. Test duration—For short-term tests (a few days) at temperatures below 150°F, paper-base gages are satisfactory and are usually more economical than other types. Extra-thin paper gages speed the curing of the bonding cement for fast application. For longer test periods (months or years), phenolic (Bakelite) or epoxy-base gages are usually used.

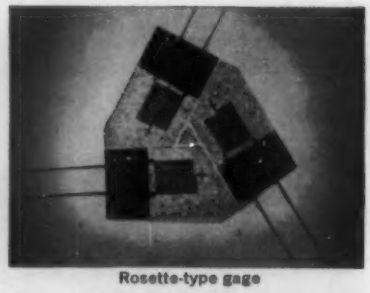
Dual-lead-type gages, with intermediate lead joints, provide good fatigue life. For better fatigue resistance and minimum hysteresis foil gages are advisable. They exhibit combined hysteresis and zero shift of less than 0.10% in strain reversals of up to ±1.5%, have generally higher fatigue resistance than equivalent wire gages.

3. Strain type and magnitude—For static strains, gages having grids of Constantan are usually used up to 600°F. For dynamic strains—particularly those of small magnitude—isoelastic gages are often recommended because of their relatively high strain sensitivity and improved fatigue resistance. Their high sensitivity to temperature change, however, limits usage to the measurement of vibratory strains unless appropriate precautions can be taken to cancel out or allow for this effect. When static strains of high magnitude (±2% to ±10%) are involved, a "post yield" gage is used.

4. Test-area geometry—Gage size depends primarily on the test space available. In general, the largest gage possible should be used. The probable strain gradient of the test area should also be considered, since the strain gage essentially averages the surface strain beneath its grid. When the test space is curved, foil gages are recommended, since they are flexible and will readily assume almost any continuous contour. When small wire gages are used, the new fine-pitch, flat-grid types are generally superior to "wrap-arounds".

5. Strain direction—Single-grid gages are used when the direction of the principal strain to be measured is known. If the strain field is biaxial and the directions are known, a 90°, 2-element rosette gage may be employed. When the strain field is unknown, a 3- or 4-element rosette may be used to determine the direction and magnitude of principal strains.

6. Output requirements—The required gage resistance and sensitivity are frequently dictated to some extent



Rosette-type gage

by the sensitivity of the measuring system to be used. Maximum gage output can be achieved by using a high-resistance gage with maximum bridge voltage.

7. Temperature compensation requirements—Strain gages are sensitive to changes in temperature as well as strain. This temperature effect on the measuring gage can often be canceled out by use of an unstressed "dummy" gage sensing identical temperatures and connected in the strain-gage circuit. In cases where a dummy gage cannot be used, some form of *self*-temperature-compensation is required. There are three general types of temperature-compensating strain gages available.

a. Self-temperature-compensating wire gages—individually compensated for specific materials and specific temperature ranges.

b. "Selected-melt" foil gages—with grids produced from a "melt" of strain-sensing material specifically selected for minimum temperature response over a specific temperature range.

c. Self-temperature-compensating foil gage—a recently developed grid design with an appropriate external circuit, which may be adjusted to provide minimum temperature response on any desired material over any temperature range.

For Engineering Assistance

When tests involve unusual conditions (e.g., high frequencies, strong magnetic or radiation fields, etc.) or necessitate special gage configurations, unusually accurate data, etc., it is advisable to consult your local SR-4® Strain Gage Sales Engineering Representative. He can also supply you with information and specific recommendations on strain-gage instrumentation (static and dynamic), cements, waterproofing compounds, and other accessories.

To obtain a free copy of the latest B-L-H Strain Gage Catalog (Feb. 1959) write Dept. 15-B

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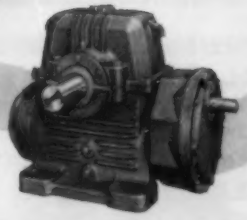
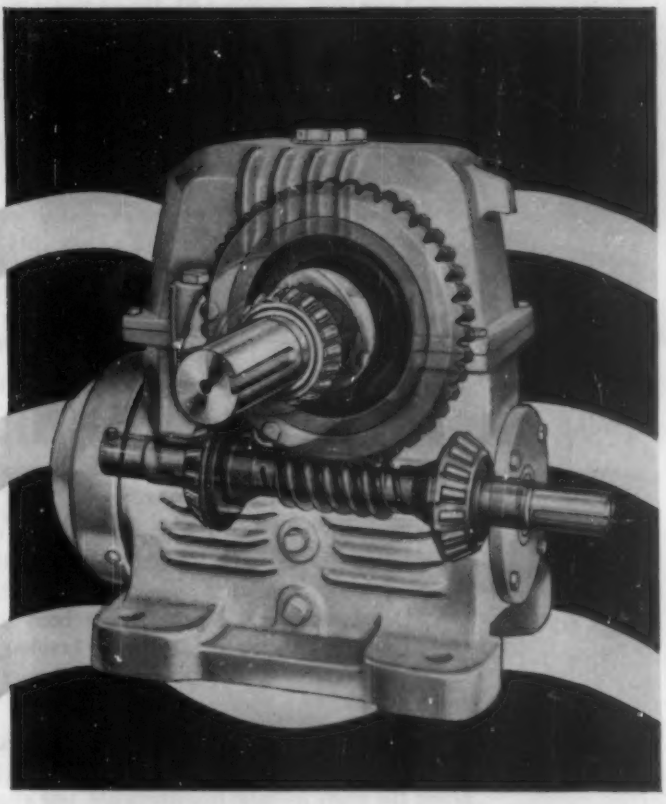
Single worm gear speed reducer



Helical worm gear speed reducer

Double worm gear speed reducer



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Industry's most complete line of worm gear speed reducers introduces more advanced refinements for reducing high motor speeds to requirements of modern production machines. Types and sizes for every right-angle need . . . single or double reduction . . . horizontal or vertical mountings . . . ratios from 5:1 to 3600:1, torque ratings up to 135,000 pound inches, up to 150 horsepower.

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FROM WASHINGTON . . .

NASA contracts face rough treatment in Congress

The House Committee on Science and Astronautics under the chairmanship of Rep Overton Brooks (D-La) is taking a critical look at the US space program. The committee will scrutinize the contract-letting practices of the National Aeronautics and Space Administration.

Failure of the NASA to throw open its records will be the key issue. Chief counsel for the house committee claims the agency has refused to let both the committee and the General Accounting Office examine contracting records on grounds of executive privilege. Cases in point are the circumstances surrounding the $102-million contract awarded to the Rocketdyne Div of North American Aviation to develop a single-chamber, 1.5-million-lb-thrust booster; and a $19.4-million contract to McDonnell Aircraft Corp for development of a space capsule for the man-in-space program, Project Mercury.

No charges of wrong-doing are made. But, the committee is miffed at NASA's secrecy. It claims that Congress intended for all NASA actions to be open for scrutiny. The agency says it has the sanctity of executive privilege, traditionally respected for such agencies. Congress seems sure to press for its way on the matter.

More scientists assigned to overseas diplomatic posts

Fourteen scientists are now assigned to US embassies, four posts are still unfilled, and three new positions are sought for fiscal 1961. Program to place scientists in diplomatic posts was revived by Congress a couple of years back. Purpose of the program is to promote scientific exchanges between US and foreign scientific groups and to advise US embassies on scientific matters. Actual collection of scientific developments is not a prime duty of the science officers.

Moscow scientific post is still unfilled. Although consultants are temporarily assigned, the two full-time officers slated for Moscow have not been assigned as yet. Deputy science officers have not been assigned to Rome or Bonn. Other officers have been sent to Stockholm, London, Rome, Paris, Tokyo, Bonn, New Delhi, Buenos Aires, Rio de Janeiro. Larger posts rate both a science officer and a deputy.

Congress will be asked to OK three new posts, in Brussels, Camberra, and South America. Location of the South American post has not been decided. Scientists filling the posts include: five physicists, one chemical engineer, one organic chemist, one inorganic chemist, two zoologists, one geophysicist, one biophysicist, one oceanographer, and one geneticist.

Controversy to continue over relative military strength of US and USSR

In the months ahead the hassle about relative military strength will not cool off. One thing to keep in mind when either side speaks—politics is an integral part of the issue.

The Administration has revised its estimate of Russian strength. Congress is challenging the action. What the Administration is saying is that the Russian missile advantage is not as large as it has been previously predicted. For example, a couple of years ago the Rand Corp predicted Russia would have 300 operational ICBM's by 1960. Now the evidence is that Russia has no such missile power.

Net result is a confused picture on just how our weaponry stacks up against the Russians. Generally, it is conceded that the US lags.

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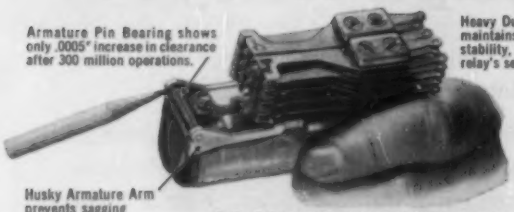
reliable performance over long life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Heavy Duty Frame maintains dimensional stability, adds to relay's sensitivity.
Husky Armature Arm prevents sagging or bending.

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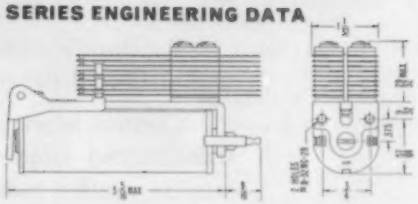
Measure the thickness of the BS series armature arm. You will find the cross section area is greater than ordinary relays of this type. Here is the kind of quality that spells dependability.

Observe that the stainless steel hinge pin runs the full width (not just half) of the armature, providing optimum bearing surface. This pin, operating in a stainless steel sleeve, shows only minimal wear during nearly a *third of a billion operations.*

Best of all, P&B quality costs no more. A whole new plant is being devoted to the production of high performance telephone type relays. Your nearest P&B sales engineer will be happy to discuss your relay problems. Call him today.

BS SERIES ENGINEERING DATA



GENERAL:
- **Breakdown Voltage:** 1000 volts rms 60 cy. min. between all elements.
- **Ambient Temperature:** −55° to +85° C. +125° C available on special order.
- **Weight:** 9 to 15 ozs.
- **Terminals:** Pierced solder lugs; Coil: One #16 AWG wire Contacts: Two #18 AWG wires
- **Enclosures:** Dust covered or sealed

CONTACTS:
- **Arrangements:** DC—up to 28 springs AC—up to 24 springs
- **Material:** ⅛" dia. twin palladium. Up to ¼" dia. single silver. Other materials on special order.
- **Load:** 4 amps at 115 volts, 60 cycle resistive
- **Pressure:** 15 grams minimum

COILS:
- **Resistance:** 100,000 ohms maximum Current: 10 amps maximum
- **Power:** DC—50 Milliwatts per movable arm. Greater sensitivity on special order. AC—17.9 volt-amps.
- **Duty:** Continuous
- **Treatment:** Centrifugal impregnation
- **Voltages:** DC—up to 300 volts with series resistor. AC—up to 250 volts, 60 cy.

MOUNTING: Two #8-32 tapped holes ¾" o.c. Other mountings on special order.

GS SERIES—Excellent sensitivity: 50 mw per movable arm minimum (DC). For applications requiring many switching elements in small space.

LS SERIES—Medium coil relay with short springs and light weight armature for fast action, reliability and long life.

TS SERIES—Short coil relay is available in AC and DC versions. Long life construction. Can be supplied (DC) with up to 20 springs (10 per stack).

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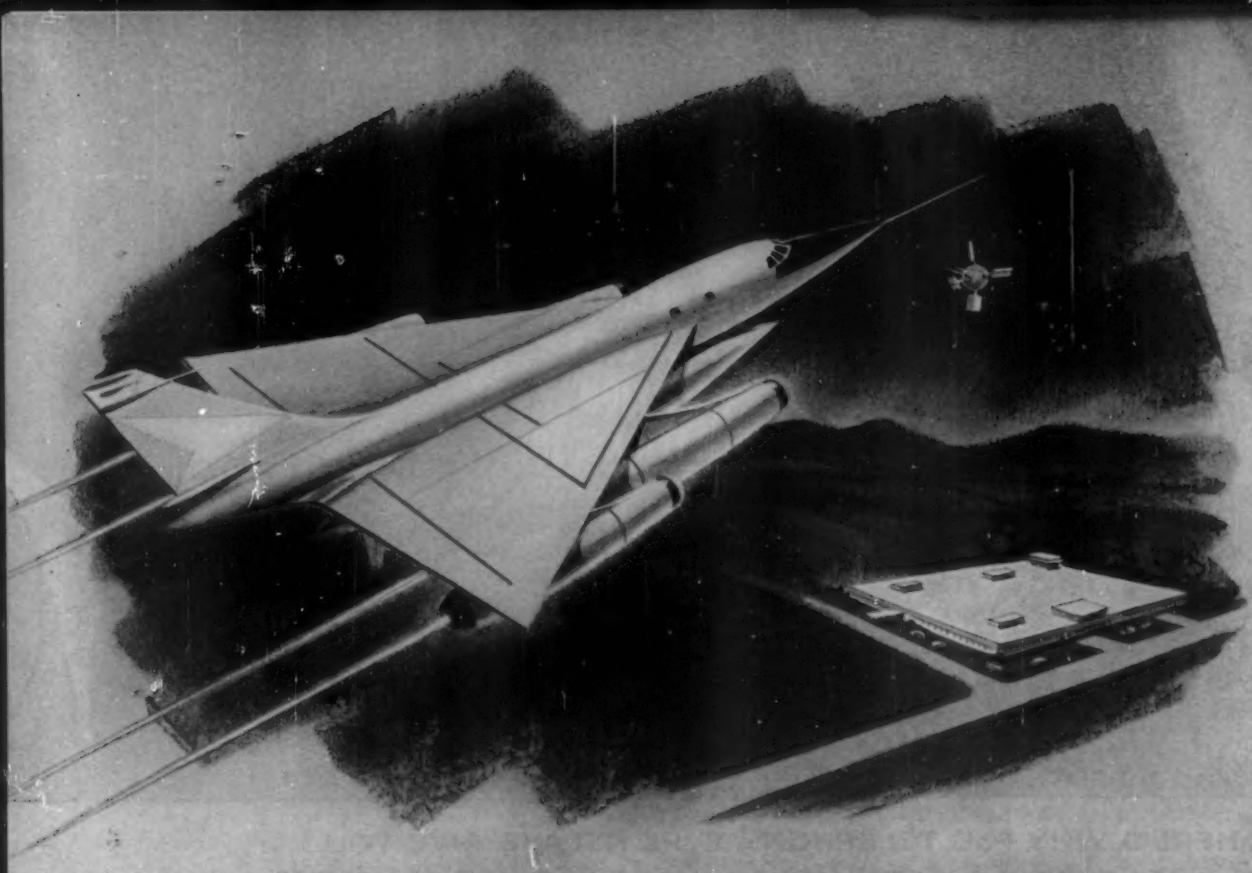

Expanding a capability. . .

Raytheon's Airborne Electronic Subdivision this month occupies a new multi-million dollar research and development laboratory.

Creative effort within this new facility will be directed at featherweight transistorized Doppler radars; altimetry and terrain clearance techniques; satellite weather radar studies; airborne early warning radars; missile boost, flight and terminal guidance problems; radiometry; and other areas.

Like the B-58's sophisticated search and Doppler radars, the systems, subsystems or equipments developed will find application in manned aircraft, missiles, drones, and a variety of space carriers.

To engineers and scientists with particular interest in this work, the new laboratory offers complete professional satisfaction in an academic environment. For immediate information on select staff appointments, write Mr. Donald H. Sweet, Engineering & Executive Placement, Raytheon, 624 S Worcester Road, Framingham, Mass. (suburban Boston).

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Colleges Want More Aid (Unrestricted) from Industry

NEW YORK—American industry gave $150 million to support colleges and universities last year according to a year-end estimate by the John Price Jones Co, which raises funds for educational institutions. Though this was an increase of $20 million over 1958, many administrators are calling for still more help from industry—and preferably with fewer strings attached.

John D. Ryder, of Michigan State University, warns: "Industry is likely to find the supply of engineers dried up at the source. We need money for staff and buildings, but we haven't been getting it. Outside of a few scholarships and fellowships, corporate aid to engineering is small. Major research support comes from government agencies."

One of the largest private aid programs is the $4 million of scholarships offered annually by General Motors. But even this enormous contribution is a lot less than the company could, and should, be doing, says one university administrator. Federal income tax laws permit companies to deduct contributions up to 5% of annual income. However, the Council for Financial Aid to Education found that of 28 companies who, in 1958, contributed as much as 1% of their net income before taxes to higher education, only nine gave 2% or more, and only three gave 5% or more.

PRIVATE AID TO PUBLIC SCHOOLS

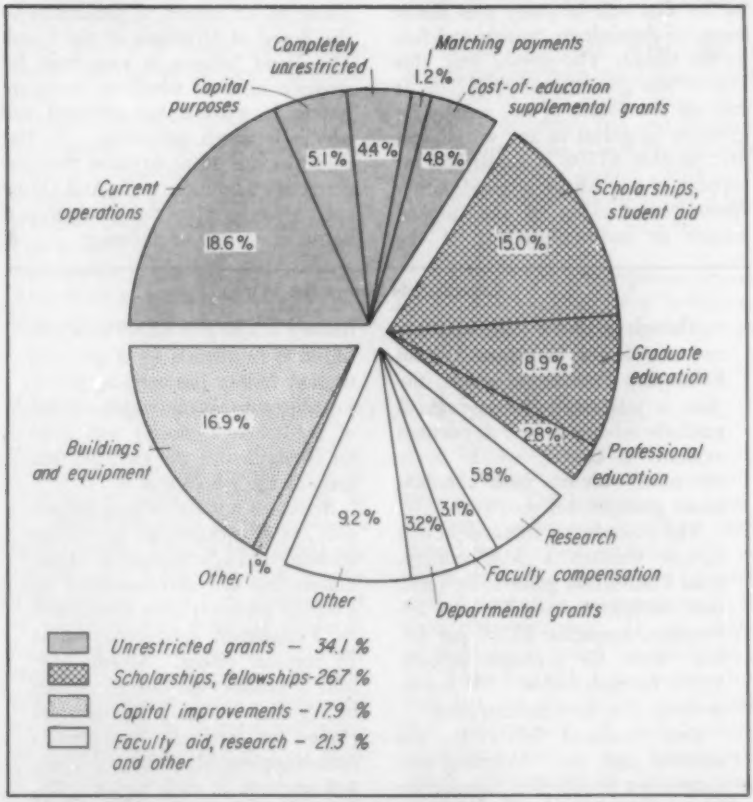
Much of the plea for corporate aid to schools has focused on the private institutions, which receive no tax support. But the tax-supported institutions, too, are appealing for more help. Robert Sproul, president emeritus of the University of California, says: "It is the public colleges and universities that have borne the brunt of increased need for both teaching and research facilities in the past century. Privately donated scholarships for undergraduates and graduates play an important role in enrolling and retaining many of our brightest students and could give outstanding foreign students an opportunity to study in the US."

During 1957-58, UCLA spent $10.3 million for research and student assistance. About $258,000 (2.5%) came from business and industry. But private foundations—many of them set up by business firms—contributed another $1.1 million (10.3%). A financial officer at Stanford emphasizes the importance of unrestricted funds. He says: "The university knows where to put the money to best use. The more sophisticated donors, usually large corporations, seem more and more to have faith in school administration as evidenced by increased unrestricted gifts."

One nationwide organization, Independent College Funds of America, has been set up especially to solicit unrestricted funds. Starting in 1948 with one regional unit in Indiana, the Fund has expanded to 40 members throughout the US. Only unrestricted grants for operating budgets—not capital budgets—are accepted by this group. Most of the proceeds go to improve faculty salaries, though the money can be applied to any purpose. Since its inception, the Fund has collected $40 million from an estimated 35,000 companies for the 480 participating colleges.

WHERE THE AID WENT

Last year, 34% of all corporate aid was free of specific designation. In its study of 352 companies, CFAE found that roughly 4% of the $49 million that they gave was completely unrestricted; 5% was for unrestricted capi-



PATTERN OF EDUCATIONAL GIVING: The Council for Financial Aid to Education surveyed 352 companies last year and found that they gave $48.8 million to education. The pie graph shows how this money was allocated.

tal purposes; and 19% was for unrestricted use in current operations. In addition, some companies match contributions made by their employes. This money is generally unrestricted and accounts for about 1% of corporate aid. Some scholarships include supplemental grants. These account for another 5% of corporate aid.

The earmarked grants, 66% of the total, included: 17% for special buildings and equipment, 15% for scholarship and student aid, and 12% for graduate and professional education. Sometimes industry supports a faculty member, thereby releasing funds to improve salaries of other professors or to cover general expenses. Gifts of equipment are occasionally given advantageously. But universities generally lead scientific research. Hence, donations of used equipment are more appropriate to high schools.

Scholarship and fellowship aid is the most common form of business assistance. When scholarships are given, the trend is toward supplementing the student stipend with an unrestricted grant to the college. (Tuition scholarships alone impose hidden costs upon the university because tuition pays only half the educational costs.) But this trend is by no means a stampede. Joe Jefferson, director of university admissions and financial aid at Columbia declares "Schools wish more companies would adopt this enlightened form of giving."

The best scholarships for undergraduates, he adds, are sponsored by General Motors. These range from $200 to $2000 depending on need of the student—based on his family's financial position, his earning power during vacations, and the full cost to him of attending the institution of his choice.

And among graduate fellowships, Jefferson says, the Woodrow Wilson National Fellowships provide a model for other donors. Educating graduate students is more expensive for the colleges than educating undergrads. Yet very few fellowships include aid to college as well as student. The Wilson program gives a winning fellow $1500 for his first year of study plus allowances for dependents, tuition and fees to the school. The second year, this Foundation gives the school $2000; it can use one fourth of this money for graduate programs in any way it sees fit. Another $1500 is earmarked for support of a graduate student—either second-year backing of the original winner or another student of the school's choice. These fellowships are limited to students who plan on a college teaching career.

WHEN CONFLICT OCCURS

Occasionally a benefactor includes terms that are restrictive, are hard to administer, or make it difficult for a student to change career goals as he develops. An example of particular interest to engineers is the newly established Fannie and John Hertz Engineering Scholarship Foundation. It started in 1957 and is supporting 67 mechanical and electric engineers in 47 colleges. In time it will be one of the largest foundations. Its purpose is "to promote the welfare and defense potential of the US by encouraging and financially assisting worthy young people to become competent mechanical and electrical engineers." To promote these goals, students are bound by certain stipulations. At least one major university, finding the terms unacceptable and difficult to administer, refused to enforce them.

The controversial provisions are: (1) The student is required to take a course in US history as prescribed by the Board of Directors of the Fund. The Fund believes it important for students to know what the American system is, what it has achieved and why it is worth defending. (2) The student must agree to serve the government in time of need. And (3) he must agree to repay the scholarship if he switches from engineering. ■

Why Schools Like GM Plans

The General Motors scholarship programs appeal to educators because it aids colleges as well as students. **In the GM College Plan,** the company maintains 304 four-year scholarships for students at 111 private and 70 public institutions selected on the basis of schools attended by GM employes. The schools have full discretion in choosing scholars. Because GM is anxious to spread aid broadly, no school can offer more than 5 scholarships in any one year. Student stipends range from $500 to $2000, depending on individual need; the school gets a grant-in-aid of $500 to $800, depending on tuition, for unrestricted use.

In GM's National Scholarship Plan, at least 100 scholarships are awarded annually to secondary-school seniors. Winners, who can select any accredited college or junior college in the US, are selected by a board of educators on the basis of Scholastic Aptitude Test scores, school records and extracurricular activities. As in the GM College Plan, scholarship values range from $200 to $2000 with supplementary grants-in-aid of $500 to $800 for the college.

Liberal Arts Shows the Way

Though graduate engineers are not eligible for **Woodrow Wilson Fellowship Foundation** grants, the plan is interesting for its aid to graduate schools as well as talented students—a largess, which many educators wish was more common in all graduate aid programs.

The Foundation attained present stature through a $24.5-million, Ford Foundation grant to be spent over the next 5 years: 45% for fellowships, averaging $2200 per fellow; 40% for graduate schools, $2000 for each fellow; 10% for recruiting; 5% for administration.

One thousand fellowships are awarded each year. Winning candidates get $1500 plus dependency allowances and tuition, the latter paid directly to the school. The fellow's school gets $2000 of which $1500 is earmarked for a graduate student (either the winning fellow for a second year or another scholar of the school's choice) and $500 for strengthening the graduate program as the school sees fit.

Selection is made entirely by persons with background in college teaching and administration. Candidates are first recommended by a college professor then interviewed by Foundation representatives at 15 regional offices. Seventy percent of scholars are directly chosen by regional officers. The rest are chosen at national headquarters from supplementary lists of qualified students in each region. Applicants can express preference for any school in US or Canada.

T-bird Lines but It's the Comet

The Lincoln Mercury entry into the smaller car market is the Comet. Billed as a new car—neither small, large, or compact—it borrows styling from all the Ford family of cars. Its 6-cyl, in-line engine has 8.7:1 compression ratio, produces 90 bhp at 4200 rpm. Unitized construction gives it a weight of about 2400 lb, some 1200 lb less than the Ford Fairlane. Gas economy is not given but is claimed to be excellent because of reduced weight and lower hp.

Radiation Detector Smaller Than Pin Head

NEW YORK—The costly, heavy, fragile radiation detectors of today may give way within the next few months to a solid-state ionization chamber that costs less than $10 per unit. Dr Stephen S. Friedland, manager, Radiation Physics Dept of Hughes Aircraft Co, revealed that the transistor-like device is essentially a very thin slice of doped silicon. When struck by a charged nuclear particle it emits an electrical pulse that can be measured and analyzed.

Operation depends on a p-n junction similar to that in miniaturized radio and television sets. Two basic changes were made to obtain the radiation device. One: high-purity silicon is used, which widens the radiation-sensitive region at the intersection of the p- and n-type material; and two, the position of the junction region is shifted towards the surface.

At present it is a particle counter. But, said Dr. Friedland, there is no reason why the device cannot be adapted to respond to gamma ray or X-ray emmission. This will be next step in the development program. Six applications of the detector were outlined for the immediate or near future.

• Space exploration. A three-dimensional package containing a myriad of detectors could transmit precise measurements of cosmic rays and the limit and nature of the Van Allen radiation belt. Now, photographic plates must be scanned to get the information, and this requires nosecone recovery.

• Military uses. A simple device—detector wafer, circuitry and battery no bigger than a flashlight—could give instant information on radio-activity in an immediate area.

• Nuclear power control. Instrumentation could give rapid response to changes, and accurate measurement of radiation level in a reactor. This would be simpler and less costly than photomultipliers or similar devices requiring about 1000-v field voltage.

• Industrial process control. Measurement, gaging, logging could be done with greater accuracy, less hazard and greater speed, and all with reduced use of radioactive material.

• Basic physical research. Determination of location, time and energy of nuclear particles in laboratory experiments.

• Cancer treatment. Measurement and control of radiation therapy in the destruction of malignant tissue.

Accuracy of the device is claimed to be less than ½ of 1% error, and it will operate with either no external voltage or only a very few volts. ■

Machine-tool Leasing to Aid Small Firms

SPRINGFIELD, VT.—A machine-tool leasing program, set up by Jones & Lamson Machine Co, may well be the answer to some of the problems facing smaller firms in the metalworking industry. Under the plan, a company can pay for a new machine out of profits derived from its products. According to Holmes H. Whitmore, executive vice president of the company, "economic forces require all industrial firms to increase productivity to meet the constantly rising costs of raw materials and labor."

Small firms should find the plan especially attractive as they are often at a competitive disadvantage when they try to accumulate sufficient capital to replace equipment or expand production. The lease plan, explained company spokesmen, lets these companies acquire new machines with no down payment, no security deposit, and no monthly payments until 30 days after shipment. It can supply all machines required by a metalworking firm. Jones & Lamson does not feel that the plan will in itself speed the obsolescence of metalworking equipment, but it may hasten necessary replacement to increase productivity. Mr. Whitmore figured that some $5 billion worth of equipment is ready for immediate replacement. ■

Damping By Laminates Opens Design Frontier

NEW YORK—A laminated fabrication that will damp resonant vibration has been demonstrated here by Barry Control Inc of Watertown, Mass. These laminates, according to Barry engineers, are one answer to a growing need for materials that can withstand shock and vibration encountered in dynamic environments. Unless such vibrations are somehow controlled, they cause excessive noise and eventually structural fatigue and component failure.

In the laminates shown by Barry, damping is achieved by placing load-bearing inserts into structural sheet or I-beams, hat-beams, etc. These inserts, which may be either identical with or different from the surrounding material, are bound to the surrounding material with a viscoelastic damping material. When the beam is flexed, the viscoelastic allows beam and insert to slip against one another. As the viscoelastic material strains in shear, it absorbs most resonance energy. The inserts sometimes run the entire length of a beam; sometimes through only a portion. And they are of varying cross-

section depending on the problem

Barry personnel will not disclose composition of the viscoelastic materials. They say that a variety of compounds having high plasticity, as well as adhesive and cohesive properties have been tested and the choice depends on design needs.

Most applications so far have been in aircraft or missiles with high-energy powerplants that create vibration over a wide range of frequencies. But engineers who discussed this development, predict the laminates will eventually have considerable effect on design practice wherever vibration is experienced.

Too often now, they say, the cure for vibration is worse than the disease. Many solutions, such as stiffening structural members or decoupling resonance systems, add substantially to weight. And often, when a structure is stiffened, local mass properties are introduced that can cause more damaging resonance than before.

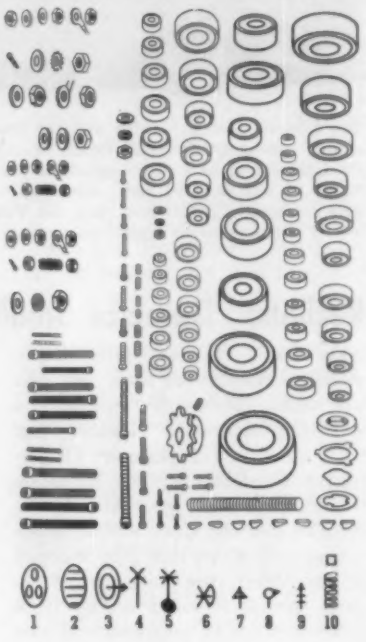
Though laminates are believed under development elsewhere, Barry officials are confident their company is unique in its accumulation of engineering design data. They point out that each structural member, whether sheet or beam, requires a particular amount of damping to minimize resonant response. Company engineers have amassed considerable data on the combinations for various vibration and loading environments.

The company is not yet producing the laminates for sale or shipment to customers. For the present, it will limit activities to analysis of customer vibration problems and design of structures to solve them. ■

3-D Shorthand Symbols Speed Part Drawing

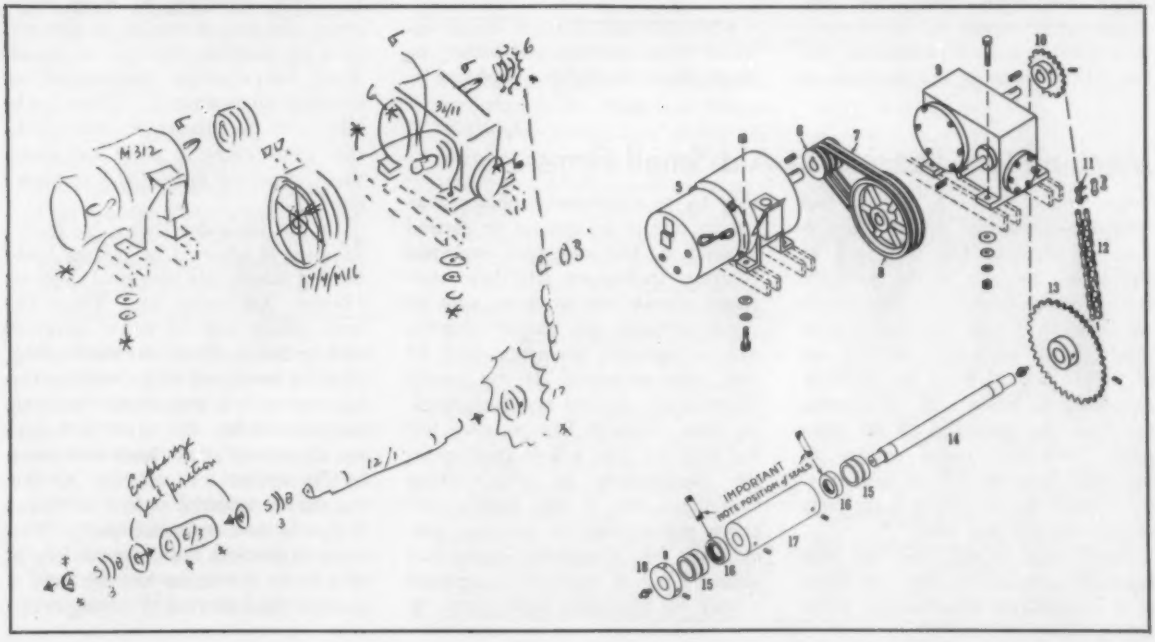
SOUTH ORANGE, NJ—A new system of shorthand symbols representing machine parts has been developed to reduce the cost of producing exploded views of machine assemblies. The system enables one man to "sketch" all parts of a complicated machine directly from the machine in a minimum amount of time, according to the inventor, Joseph Spielvogel. Exploded views, widely used to illustrate service and repair-parts manuals, enable even unskilled persons to identify and order replacement parts, and to assemble machines.

The new system, Spielvogel says, eliminates assembly drawings; facilitates use of drawings in non-English-speaking countries; and permits many problems to be solved by phone, thus reducing machine downtime and eliminating service trips.



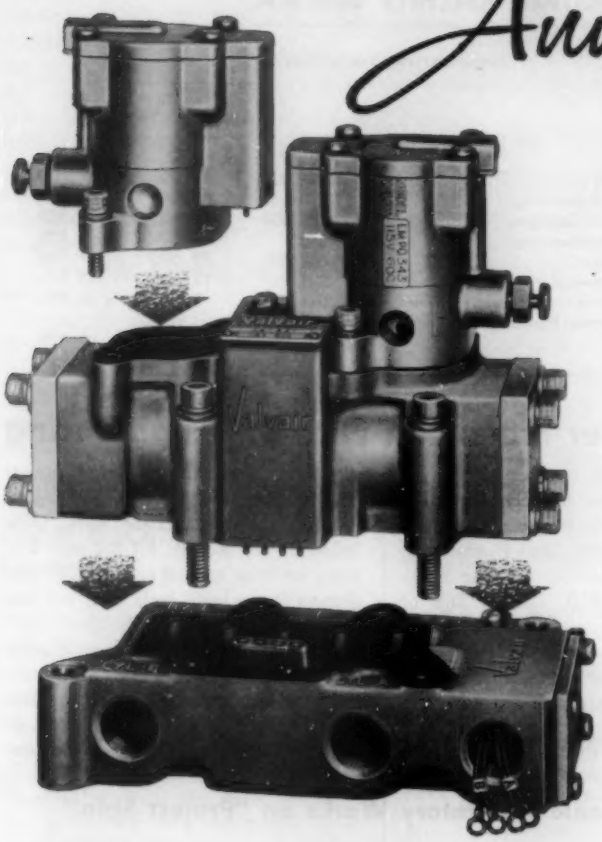
SHORTHAND "SKETCH" shows use of symbols representing standard hardware, purchased-parts reference symbols, relative sizes and other pertinent data (left). Translation of shorthand drawing notes (right) produces a conventional exploded view of assembly.

SYMBOLS FOR SOME STANDARD PARTS (above) include: ball-bearing, needle bearing, oil seal and direction, square-head screw, hex head screw, hex stop nut, straight zerk fitting, 90° zerk fitting, cone point set screw, square wire spring. Above are a selection of parts for pasteup.



Announcing

VALVAIR® ½" NPT PLUG-IN VALVES



MODEL PD-441 shown. 4-way single or double pilot-operated types, for sub-base or manifold mounting. Aluminum and stainless steel components assure multi-million cycle dependability. Interchangeable pilots, with coils guaranteed against burn-out for life of valve, fit any plug-in Speed King. Coils for ac or dc, any voltage . . . 35 — 200 psi range . . . integral junction box . . . optional manual over-ride, common or separate exhaust ports, sub-base connected external pilot supply . . . ¾ in. exhaust ports, ½ or ¾ in. inlet and cylinder ports . . . valve meets JIC standards.

Based on the service-proved design principle of the Speed King ¼ in. plug-in Valvair's ½ - ¾ in. plug-in valve series provides plug-in convenience and versatility to a wider range of control valve applications.

Electrical and pneumatic circuits are completed automatically when valve and pilot are plugged in . . . bolted down. The result — cost-cutting reduction of original installation and maintenance time. All power connections are made permanently in sub-base or manifold . . . there's no need to disturb piping or wiring for quick in-service maintenance.

What's more, advanced design shortens stroke . . . speeds response. Separate coded (4-wire) circuits on double solenoid models meet JIC requirements. Flow area through valve and sub-base equals that of full ½ in. pipe.

Whether your control valve applications are on the drawing board or now in service, it'll pay you to investigate the advantages of Valvair plug-in design. A call to your near-by Valvair field office will bring prompt application engineering recommendations.

For more information, write for Bulletin SPL. Address Dept. PE-260, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio

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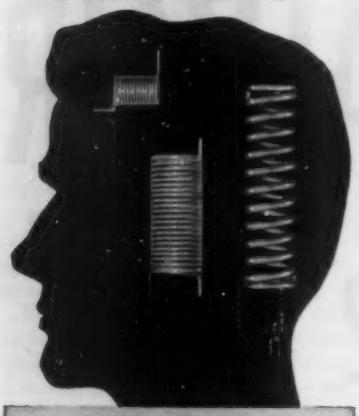
SPRINGS ON YOUR MIND?



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THE ENGINEERING WEEK

Engineering Enrollments

	Academic Year		
	1957	1958	1959
Freshmen—All Colleges	729,000	781,000	827,000
Change from previous year	.....	+7.0%	+5.9%
Male Freshmen—All Colleges	445,000	468,500	490,500
Change from previous year	.....	+5.0%	+4.7%
Engineering Freshmen	79,000	70,000	67,700
Change from previous year	.....	−11.1%	−3.5%
Engineering Freshmen Proportion of all Freshmen	10.8%	9.0%	8.8%
Engineering Freshmen Proportion of all Male Freshmen	17.8%	15.0%	13.6%

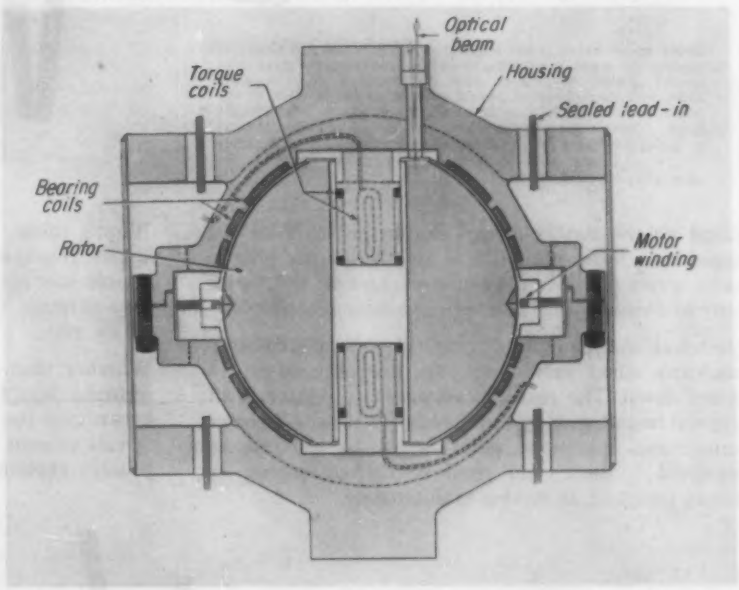
Still Fewer Freshmen Entering Engineering

NEW YORK—The number of new engineering students in US colleges declined in 1959 for the second consecutive year, reports the Engineering Manpower Commission of the Engineers Joint Council. In the face of the increasing national demand for engineers, the commission says, this trend is cause for alarm, especially if the US hopes to catch up with the Soviet Union during the 1960s.

According to the report, freshman engineering enrollments were down 3% last year compared to 1958; and enrollments during 1958 were 11% below 1957. Result: for the next five years we may expect only 37,000 engineers to graduate each year, not the 43,000 predicted in 1958.

Of most concern to the commission is the limitation on supply of future technical manpower. They say that only 17% of the students of college age each year have aptitude for en-

New Gyrogenic Laboratory Works on "Project Spin"



Cutaway shows design features of cryogenic gyroscope under development by GE's General Engineering Laboratory. Superconductivity induced by temperatures near absolute zero makes possible suspension of the rotor solely in a magnetic field. Eliminating mechanical bearings, the design reduces electrical losses and friction almost to zero. Rotational speeds up to 20,000 rpm inside a high vacuum are predicted. Future posibilities of cryogenics include: microminiature switching units for shoebox-size computers; noiseless, drift-free dc-ac amplifiers; and superconductive power lines that could carry "perhaps 10,000 amps" over a ½-in. cable.

gineering, and that only 2% of these ever enroll. At the same time, the demand for engineers will be increasing at a far greater rate than college age population. Unless new factors come into play—such as increased utilization of women who represent about half of the potential 17%—the US capacity for providing engineering manpower will be severely crimped, at least until 1965.

To ease the situation, the commission suggests:

- Increase recognition of engineers at government level.
- Publicize the advantages of engineering careers through parents, students, guidance counselors, industry and government. ■

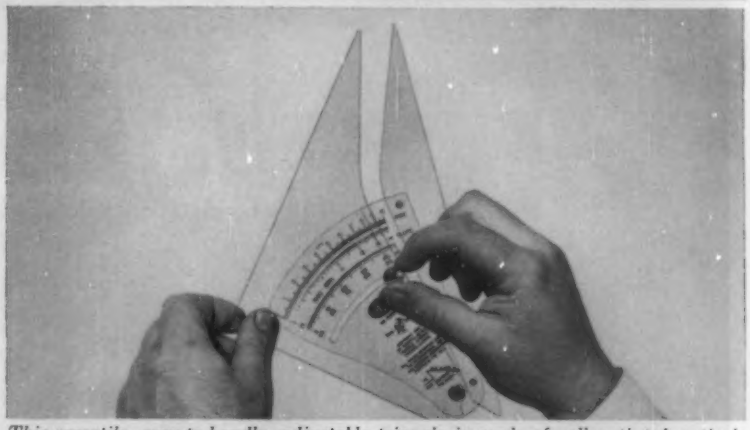
New Backbone for Epoxies

NEW YORK—An epoxy-resin series has been devised with radically new construction that may bridge the gap between thermoplastic and thermosetting plastics. Developed by Food Machinery and Chemical Corp, these new "Oxiron" resins are essentially epoxidized polyolefins—the same chemical family that has bred new tough, rigid thermoplastics like high-density polyethylene and polypropylene. This combination results in a unique molecular structure, with reaction points available both internally and externally along the hydrocarbon chain, or "backbone." This improves strength through greater crosslinking, and opens the way for combination with thermoplastic materials like vinyls and nitriles.

When cured, the new epoxies are lighter and have greatly improved high-temperature resistance, according to FMC researchers. The heat-distortion curve is much flatter and the loss of strength in aging is much lower than for conventional epoxies: heat-distortion temperature for peroxide-cured Oxiron epoxies can be as high as 188 C, and flexural strength after 250 hrs at 150 C drops to about 14,000 psi.

Because of longer pot life, the new series is expected to be a boon to pre-impregnated reinforcing materials. Cost, which is high at this stage of development, is expected to drop to about 65 cents per lb, making the resins directly competitive with standard laminating materials. Further uses are insulation, molding, adhesives, coatings and castings. ■

DRAFTING TRENDS



This versatile, easy-to-handle, adjustable triangle is made of yellow-tinted optical-grade acrylic plastic. A clean-cut oval track fitted with metal knurled knob assures ease of operation and lasting tight fit.

New combination protractor-triangle speeds up drafting

Architects, Engineers, Builders, Field Surveyors, Mathematicians—anyone who develops solutions to measurement problems indirectly to determine a wanted measurement graphically or mathematically—will find the Trig-Matk Adjustable Triangle a handy tool. It eliminates much of the graphic work necessary in estimating results or in checking for correct answers.

Versatility with accuracy

Basically the new POST Trig-Matk Adjustable Triangle is a mathematician's tool—accurate to three decimal places.

It combines the functions of a protractor and a triangle into a simple unit, with two fundamental trigonometric relationships of a right triangle. The Trig-Matk provides accuracy within 0.1% in problems dealing with any of the six trigonometric ratios of the sides of a right triangle.

The adjustable protractor has three sets of graduations. One set is graduated in half degrees, labeled *Degrees*, and permits the use of the Trig-Matk as a protractor setting for determining any angle from 0 to 90 degrees.

The second set of graduations, labeled *Slope*, shows directly the *Secant* trigonometric ratio of the angle indicated on the degree scale. The third scale, labeled *Rise*, indicates directly the *Tangent* trigonometric ratio shown on the degree scale.

Examples

This new tool has a host of drafting and engineering applications. Highway designers find the Trig-Matk very useful when making cross sections of roadways at ground level or below. By

An indicated angle of 40 degrees on the Trig-Matk (1589) shows directly that the Rise is 8.4 to the base of 10.

setting the *Slope* scale to the degree desired, road-curve grades are automatically determined. The protractor can be used to determine the angle of highway ingress and egress lanes.

Structural Engineers will find the Trig-Matk Adjustable Triangle a simple tool, eliminating the use of both a scale and individual triangles. In addition to the time saved, many of the errors usually associated with the older method are avoided. The Trig-Matk design eliminates the need of frequent reference to handbooks for information on various bevels.

Two Bases

The Trig-Matk No. 1589-12 has a 12" base scale for handy calculation in terms of feet and inches. Number 1589-10 has a metric base scale of 10.

Keep posted on all the latest trends in drafting. Consult your local POST dealer, or write to Frederick Post Co., 3642 North Avondale Ave., Chicago 18, Ill.

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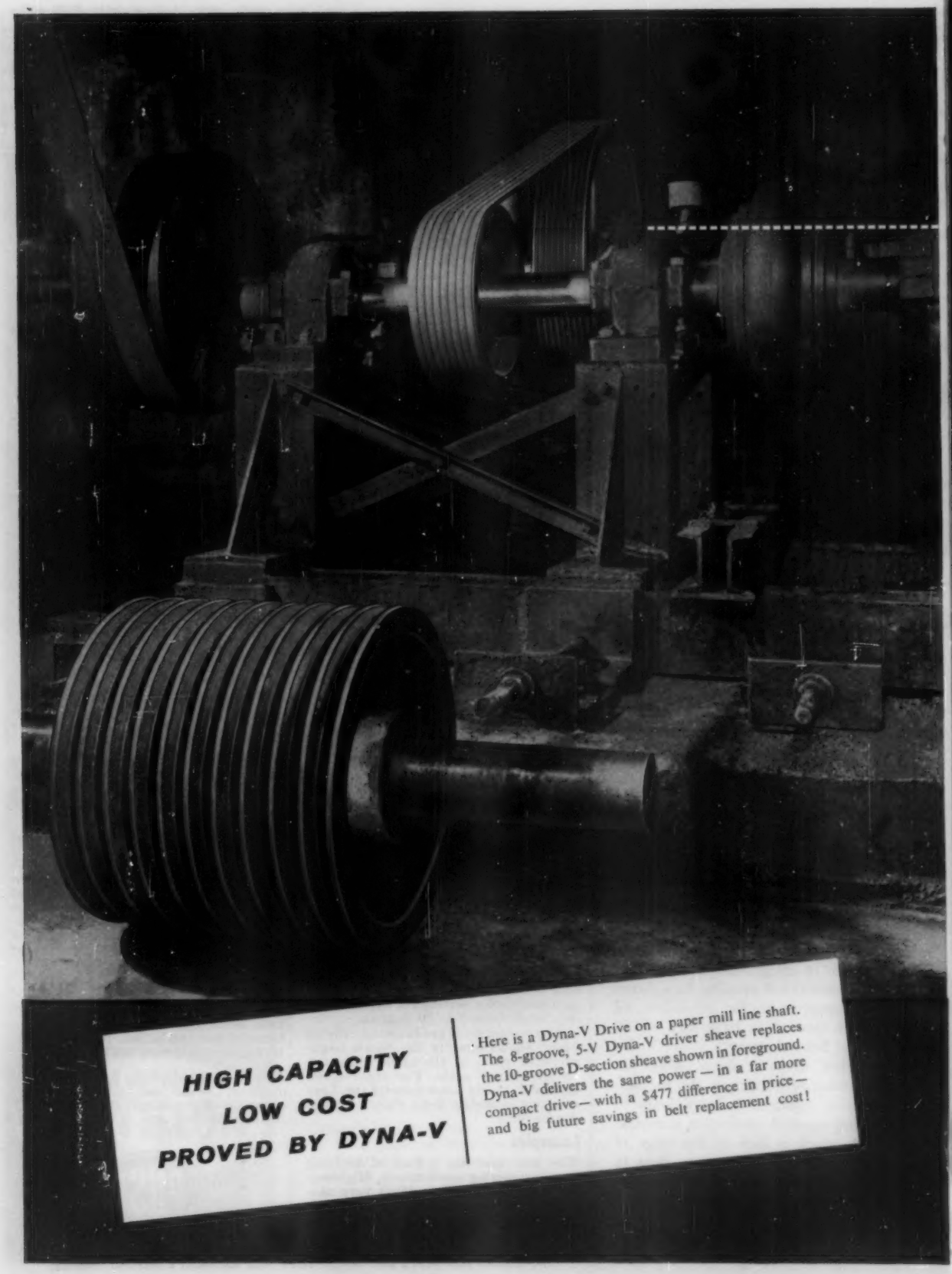
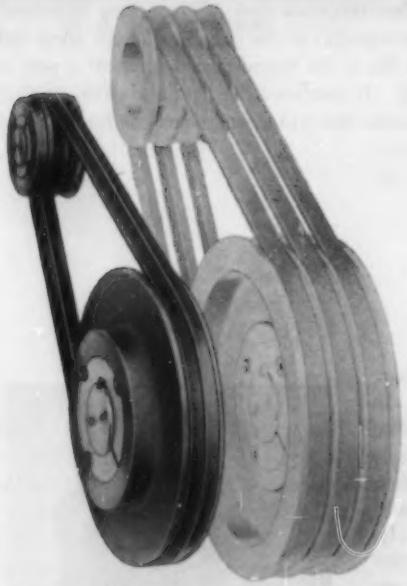


HIGH CAPACITY
LOW COST
PROVED BY DYNA-V

Here is a Dyna-V Drive on a paper mill line shaft. The 8-groove, 5-V Dyna-V driver sheave replaces the 10-groove D-section sheave shown in foreground. Dyna-V delivers the same power — in a far more compact drive — with a $477 difference in price — and big future savings in belt replacement cost!

Dyna V

THE NEW MONEY-SAVING IDEA IN V-BELT DRIVES!



Dyna-V compared with big-groove drive for same hp. Dyna-V is capable of handling 3 times as much hp in the same space! Dyna-V Drives are available for capacities from 1 to 1500 hp.

The day of big-groove sheaves and belts is passing. The new idea of compact V-belt drives—Dyna-V—introduced by Dodge just a few short months ago, is taking the country by storm. Thousands of Dyna-V Drives are at work in industry everywhere, carrying their loads easily, dependably, and proving their ability to *deliver more horsepower per dollar!*

Dyna-V utilizes the full performance possibilities of today's great synthetic fibers for belts—and modern metals for sheaves. Narrow belt top widths team up with narrow sheave grooves to create Dyna-V compactness. Narrow grooves reduce face width—save weight. Costs are lowered. Smaller diameter sheaves and shorter center distances multiply savings. With Dyna-V you cut costs on most initial installations and economize on belt replacements as well. In medium and high hp ranges these savings can be as much as 30%.

Dyna-V Sheaves decrease shaft overhang—increase bearing life. And Dyna-V Belts possess all premium qualities. Conditions requiring oil, heat, moisture resistance or static conductivity are met by Dyna-V's one grade—the finest. Ask your local Dodge Distributor. Or write us for Dyna-V Bulletin.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery".

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POINTS OF VIEW

THE QUESTION: *Have Metals Taken*

W H Detlefs
Mgr, New Product Market
Development Dept
Union Carbide Plastics Co

"Metals have not taken . . .

any markets away from the plastics industry. On the contrary, I would say that if there has been any 'taking,' the plastics industry has done it. The newer, stronger, more versatile plastics, have made inroads on many areas once considered the private domain of the metals industry. One graphic example in the appliance industry is the washing-machine agitator. Once it was made of light metal; now it is made of less costly, more chemically resistant and more practical phenolic plastics. More recently, in the automotive field, plastics have replaced metals in "kick" panelings. Very soon, we believe, polyethylene will become the prime material used to package detergents, replacing the familiar metal can.

"The future will probably also bring the development of new polymers which, like metals, may be cold drawn and formed by impact. Such developments would indicate that the 'taking away' will continue on an even larger scale in the future. However, it is our belief that these developments will serve primarily as a further incentive that will continue to stimulate the aggressive competition so essential to the growth of both these industries. An excellent example of this is the recent introduction of a new material, vinyl-coated steel sheeting. It combines the best properties of plastics and metals to create a new product that will mean greater use for both materials."

"It has been all the other way . . .

Plastic engineering materials have been adopted for a wide range of mechanical applications and, when properly applied, have held this business. In thermoplastics, which is DuPont's concern, the growing competition between metals and resins rests largely on a paradox. Despite the greatly improved, well-balanced properties of the newer thermoplastics, it is their nonmetal properties which enable them to compete with metals. DuPont's newest thermoplastic, Delrin acetal resin, provides a case in point. Its rigidity, strength, dimensional stability, and other outstanding properties make Delrin literally 'metal-like.' But it can compete with zinc, brass, or aluminum primarily because of its nonmetal properties—its processability, corrosion resistance, low coefficient of friction, integral color, light weight.

"It is this dual utility—metal-like properties plus nonmetal performance features—that makes the newer thermoplastics so attractive to product designers and engineers."

Milton J Roedel
Mgr, Market Development
Polychemicals Dept
E I duPont de Nemours & Co

Markets Away From Plastics?

Dr A M Gemassmer
Technical Director
Mobay Chemical Co

"For any material to survive . . .

in today's complex industrial environment, it has to have two or three outstanding qualifications. Few materials have more than this to offer, so today there is no clear advantage for any one material but rather a kind of competitive, closed-circuit battle that no one really wins.

"There are countless cases on record, documenting a back-and-forth swing from metal to plastic in some application; a search which frequently ends in a combination design putting both materials to excellent advantage. Shortcomings of both materials are avoided. When this is done properly it represents a giant step forward in product design which benefits both industries as well as the consumer.

"An excellent example is a steel wheel with a cast urethane-elastomer tire for mechanical trucks. The elastomer outwears a steel rim many times. By using both materials together you achieve the interesting paradox of an engineered unit that is superior to the sum of its component parts. Another example is a machined-steel gear meshed with a urethane-elastomer gear that operates silently, eliminates lubrication, permits broader tolerances in design and outwears all-metal or all-elastomer mated parts. Plastic-lined pipe and sandwich-type curtain wall panels—combining urethane-foam, steel and aluminum components—are other noteworthy examples of what a joint effort across industry lines can produce.

"In most mechanical devices, metals are still the logical choice for the internal or external structural skeleton, while plastics excel as the 'ligaments, joints, marrow, cartilage and skin' that provides greater utility and service life to the unit."

"I am not aware of any markets . . .

in which plastics have become entrenched, and then have been forced to give way to metals. I am willing to concede that new developments in metals might result in the loss of small areas of markets in which plastics are now active. But more to the point, the plastics industry has grown rapidly and I believe that this strong growth trend will continue. The plastics industry expects to have sold 5.5 billion lb of its products during 1959, and to boost that figure by 10% in 1960. It has made a place for itself on the industrial scene by doing jobs better than other materials, including metals.

"There are numerous instances where plastics have invaded fields that were traditionally the province of metals. Just a few examples are housings, bearings, containers, pipe and many different extruded and molded parts. Plastics have also teamed with metals, and in the process have expanded the marketing areas of both materials. Vinyl-to-metal laminates, for example, are now being used for a range of products from television cabinets to auto trim parts."

Wesley S Coe
Director, Research and Development
Naugatuck Chemical Div
United States Rubber Co

Republic High-Performance Titanium for the X-15

In a number of highly stressed components subject to extreme high and low temperature fluctuations, *high-performance* titanium in the X-15 Research Vehicle will help take man higher and faster than he has ever been before.

Republic Steel—a leading supplier of titanium, and the nation's largest producer of stainless and alloy steels—is supplying North American Aviation with Type 110A titanium for internal structures on the X-15 project.

Let us help you utilize *high-performance* metals to increase strength, resist heat, or trim weight. Write Republic Steel, Dept. PE -8591, 1441 Republic Building, Cleveland 1, Ohio.
Please indicate if you would like a titanium metallurgist to call.

REPUBLIC STEEL *Where Steels are*

FIRST POWERED FLIGHT of the North American X-15 came on September 21, 1959, over Edwards AFB. Carrying a full load of fuel (note frost from liquid oxygen at top and bottom of fuselage), the X-15 flew under power for 3.5 minutes at speeds in excess of Mach 2.

REPUBLIC STAINLESS STEEL is used in leading edges of the Convair 880's vertical fin and horizontal stabilizer where anti-icing is accomplished through electrical heating of the metal. Use of Republic ENDURO® Stainless Steel increases strength and heat-resistance, permits thinner, lighter gages. Types 301 and 302 are readily formed into desired shapes by cold forming, drawing, and bending operations.

REPUBLIC'S NEW HIGH STRENGTH POWDER, TYPE HS6460

is ideal for sinterings of highly stressed components. Provides minimum tensile strength of 60,000 psi at 6.4 density as sintered . . . 100,000 psi after heat treatment. Maximum of .004% shrinkage from die size at 6.4 density. Available in quantities up to and including 12 tons or multiples. Can be used with existing operating equipment.

REPUBLIC VACUUM-MELTED ALLOYS heat treated to tensile strength levels of 270,000 to 300,000 psi are produced in fifteen thousand-pound heats for missiles such as the Minuteman. Vacuum arc process minimizes segregation and center porosity. Nonmetallic inclusions are reduced in number and size. Transverse ductility at high strength levels is also greatly improved.

Made to Meet the Challenge of Acceleration

REPUBLIC STEEL

CIRCLE 27 ON READER SERVICE CARD

(Advertisement)
No. 10 of a series

Eastman 910 Adhesive solves another production bottleneck

ASCOP Division of Electro-Mechanical Research, Inc., Princeton, N. J., makes an unique digital encoder which converts any shaft position directly into a binary code output. Operating up to 10,000 r.p.m., the tiny instrument is a masterpiece of compact design.

Space limitations require a flush connection between a vinyl plastic sleeve containing the output wires and an aluminum cover plate. Eastman 910 Adhesive plus imaginative thinking solved the problem.

In production, the end of the sleeve is inserted through a hole in the cover plate, adhesive is applied around the hole and a flaring tool forces the end of the tubing back against the plate. *A strong bond forms in 2-3 minutes.*

Eastman 910 Adhesive is making possible faster, more economical assembly line operations and new design approaches for many products. It is ideal where extreme speed of setting is important, or where design requirements involve joining small surfaces, complex mechanical fasteners or heat-sensitive elements.

Eastman 910 Adhesive is simple to use. No mixing, heat or pressure is required. Upon spreading into a thin film between two surfaces, setting begins immediately. With most materials, strong bonds are made in minutes.

What production or design problem can this unique adhesive solve for you?

For a trial quantity (⅓-oz.) send five dollars to Armstrong Cork Co., Industrial Adhesives Div., 9102 Irvin Street, Lancaster, Pa., or to Eastman Chemical Products, Inc., Chemicals Div., Dept. P-2, Kingsport, Tenn. (Not for drug use)

See Sweet's 1960 Prod. Des. File, 7/E

READER TO EDITOR

Engineers vs Draftsmen

To the Editor:

To my mind it is not "Engineers vs Draftsmen" (Dec 14, p 40). Every engineer is more or less of a draftsman and every draftsman more or less of an engineer. They should not be playing a game one against the other (although it happens) but working together for the improvement and advancement of their work.

I doubt if a single standard language for drafting will ever become a reality, simply because each of the hundreds of divisions in the metalworking field alone has a nomenclature of its own. Again, metalworking is only one of the trades employing draftsmen. From another angle, any standard language should be as understandable as possible to the ultimate user. It is well to keep in mind that a drawing may be used in one circumstance to make only one piece and in another to make a million. The first may be part of a bridge and the latter part of a radio. A single standard of communication to cover both of these situations efficiently would have to be exceedingly comprehensive. We should not sacrifice clarity for standardization. There is an old shop saying that a job made right the first time will show the cheaper cost and the better quality. As Mr Grisvard mentions, a tradesman can learn his job fairly well in three or four years and is competent to deal with most situations.—D H Parker
Windsor, Vt

To the Editor:

As the catalyst between engineering theory and physical reality, the draftsman makes not only the translation of which Mr Smith speaks, but also does the majority of the editing so necessary to the communication involved. The title "Engineer," on any level, does not carry with it an inherent capability to communicate correctly that which is to be translated. A draftsman with several years of training and experience does not change the theory in his translation, but does edit it to the point of comprehension by those required to produce the finished product.

I have yet to read an engineer-written text, which has been published for consumption by those other than engineers, that has not passed through a similar "editing" process. As long as translation is necessary, I am sure engineers will continue to receive the editing services of experienced and trained draftsmen which will enable them to receive the plaudits and rewards of their efforts.—D W Hickey
Designer, Philco Corp

To the Editor:

It all boils down to the definition of an "engineer" or a "draftsman." If a man with an engineering degree makes a drawing, is he a "draftsman"? Is an "engineer" a fellow who goes through 4 years of prescribed schooling and has a mortarboard placed on his head? Or does he have to achieve a professional license by working 6 years and passing a comprehensive examination before he becomes a full-fledged engineer? Just who is an "engineer"? Small design-engineering firms usually hire first-rate engineers who have specialized in design work, and use these men to design machines and make the drawings. Just because they make drawings, are these men not engineers? I've seen many a graduate engineer working on a drawing board, making formal drawings. Are these men "engineers" or "draftsmen"? The dividing line is very thin at times.

Perhaps it would be wiser to delete the word "draftsman" from the engineering vocabulary. I once heard a group of women, whose function it was to make dress patterns, referred to as "draftsmen." A cartoonist is a "draftsman" also. The term is about as meaningful as "bench worker" or "desk worker." I feel that a man who designs, even if it's a bracket to hold up a piece of equipment, is engaging in engineering and should be classified as an engineer of some grade or other.
—Clive E Reed
Design engineer
Brookhaven National Laboratory
Upton, NY

To the Editor:

In answer to Mr Grisvard of Seattle, Washington, there is a drafting organization in existence and has been for six years. We of the organization are more than gratified to hear that someone wants help in organizing (not unionizing) such a group. Our purpose is the betterment of drafting and we start in the schools. At present our groups spread from Corpus Christi, Texas to Billings, Montana. We have 15 clubs at present and more to come. We have 5 colleges associated with us and most clubs have student chapters as part of the parent club.—Theodore S Gohrs
President, Oklahoma City
Assoc Prof Draftsman

Driver's Training Car

To the Editor:

In your Nov 16 issue, p 47, Mr F Buehler suggests development of a trainer for automobile drivers. I would like to point out that there is a classroom trainer on the market known as the Aetna Driver Trainer.

A few research laboratories have some devices that more realistically simulate driving. Our institute is in the process of developing a high-fidelity driving simulator; a device that will include such features as unprogrammed visual presentation, simulation of inertia forces, etc.

At present our research setup consists of a real car placed on a chassis dynamometer, visual presentation (film) front and rear, and instrumentation for measuring the driver's responses. Because the car is placed on a chassis dynamometer and is

actually running, a driver performs all the functions he would perform during an actual ride.

—Charles K Wojcik
Associate research engineer
Univ of California

To the Editor:

I note with interest the suggestion made by Mr F Buehler in your "Why Don't They" column of your Nov 16 issue. The Aetna Drivotrainer, as manufactured by the Automatic Voting Machine Div of Rockwell Mfg Co in Jamestown, NY, is now in use in more than 70 highschools throughout the country. It is also being used by the Air Force at Geiger Field, Spokane, Wash, and by the Manufacturers Light and Heat Co of Pittsburgh in its Fleet Safety Program.

—M O Doolittle, Jr
Rockwell Mfg Co
Pittsburgh

Creative Dissent

To the Editor:

I was interested in your article, "Creativity," which appeared in the issue of August 24th, p 20. I take issue with your statement concerning "the older man." I retired as chief of the mechanical section of Rome Cable's Research Center here at Rome on June 1st and am now giving my time to a small new company which I founded about two years ago. Am still retained by Rome Cable part time as a consultant.

Of course, it is said that "it's the exception that proves the rule." In my case my productivity in new and inventive ideas has never been greater than at the present time. I have had more patents issued in the past five years than in any similar previous period.

—Maurice G Steele
Rome, NY

COMING EVENTS

FEBRUARY

10-11 . . . . Institute of Radio Engineers, 1960 Solid State Circuits Conference, Philadelphia, Penna.

24-25 . . . . Malleable Founders Society, Technical and Operating Conference, Cleveland, Ohio.

MARCH

6-9 . . . . American Society of Mechanical Engineers, Gas Turbine Power and Hydraulic Conference, Rice Hotel, Houston, Texas.

7-8 . . . . Steel Founders Society of America, 58th Annual Meeting, Drake Hotel, Chicago.

15-17 . . . . Society of Automotive Engineers, National Automotive Meeting, Sheraton-Cadillac, Detroit, Mich.

29-31 . . . . American Society of Mechanical Engineers, American Power Conference, Hotel Sherman, Chicago, Ill.

Typical Control Functions solved by AIR CIRCUITRY

Westinghouse Accessory Devices

Westinghouse Air Brake Company manufactures a complete line of accessory air devices, in addition to basic devices that use air only to extend or retract cylinder rods. These devices, functioning between the primary sender and final positioner, control air flow and pressure to provide the most complex sequences of operation. Their design, however, is not complex. The few wearing parts, if any, can be replaced by any reliable mechanic.

Westinghouse accessory devices in addition to many types of air directional and pressure control valves, positioners and piping equipment makes available to you one source for a full line of everything you need to install and operate an efficient air circuit. For more information ask for Catalog DO-00-2.

APPLICATIONS—The illustrated devices in conjunction with other air circuit components have been used successfully by all types of industry. Manufacturing processes, marine equipment, drilling operations, construction machinery and transportation facilities have all enjoyed the benefits of Westinghouse Pneumatic Controls. We will be glad to demonstrate how you too can benefit.

What is Air Circuitry?

This is the Westinghouse term for application of pneumatic control systems to industrial production operations. Safe, economical, precise AIR CIRCUITRY is now being used to solve the most rigorous and complex control problems in industry. Westinghouse Air Brake has pioneered the application and development of air control for more than 80 years. Today our engineers can design an air circuit which will help you boost production and cut costs in your plant or shop.

1. QUICK RELEASE—Remotely operated vent valves permit quicker operation for release of cylinders, clutches, brakes, etc. The Quick Release Valve provides a large exhaust port as close as practical to the air volume to be vented instead of back through the controlling device.

2. PRESSURE RELAY—Large quantities of air are relayed or repeated by the Relay Valve at pressures corresponding to the control pressures applied to them. The Relay Valve increases the speed of operation and reduces transmission times in long control lines.

3. CIRCUIT SEGREGATION—The Double Check Valve connects two segregated lines to a common third line and still maintains the segregation. Air flowing from one line to the common line seals off the unused line by means of an internal shuttle. Controlling a single operation from two or more stations is an example.

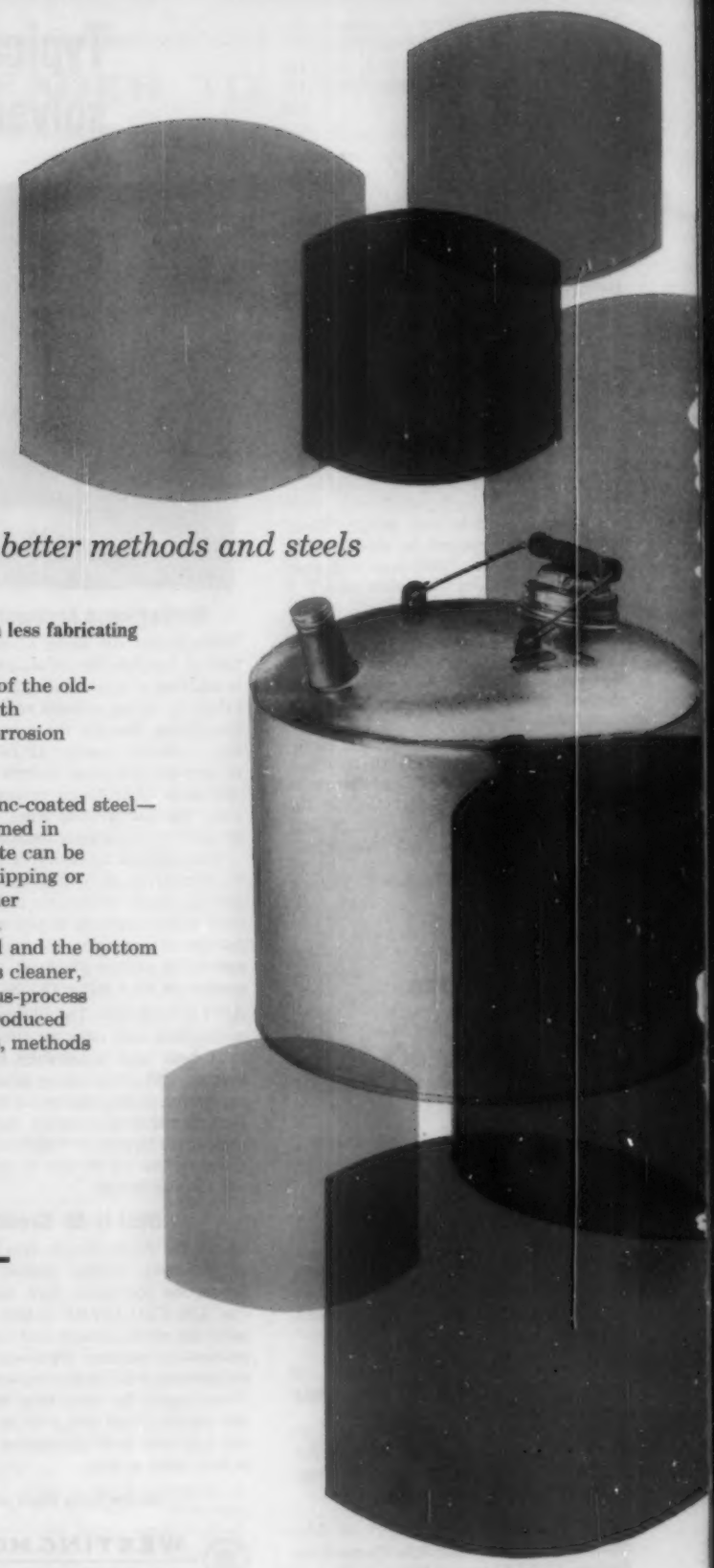
4. TIMING—The Westinghouse Floreg Valve is an adjustable device that controls the rate at which air can flow in one direction through the circuit, yet allows free flow in the opposite direction. It is used to time, synchronize or co-ordinate the operations of a circuit.

5. INTERLOCK—To insure one function is performed and conditions are satisfactory before another function is initiated, the H-5 RELAYAIR® Valve may be used. A pilot operated, directional control valve with various spring settings, this device requires a prescribed pressure be present in its control chamber before it operates.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor

WESTINGHOUSE AIR BRAKE COMPANY
INDUSTRIAL PRODUCTS DIVISION, WILMERDING, PENNSYLVANIA

CIRCLE 29 ON READER SERVICE CARD



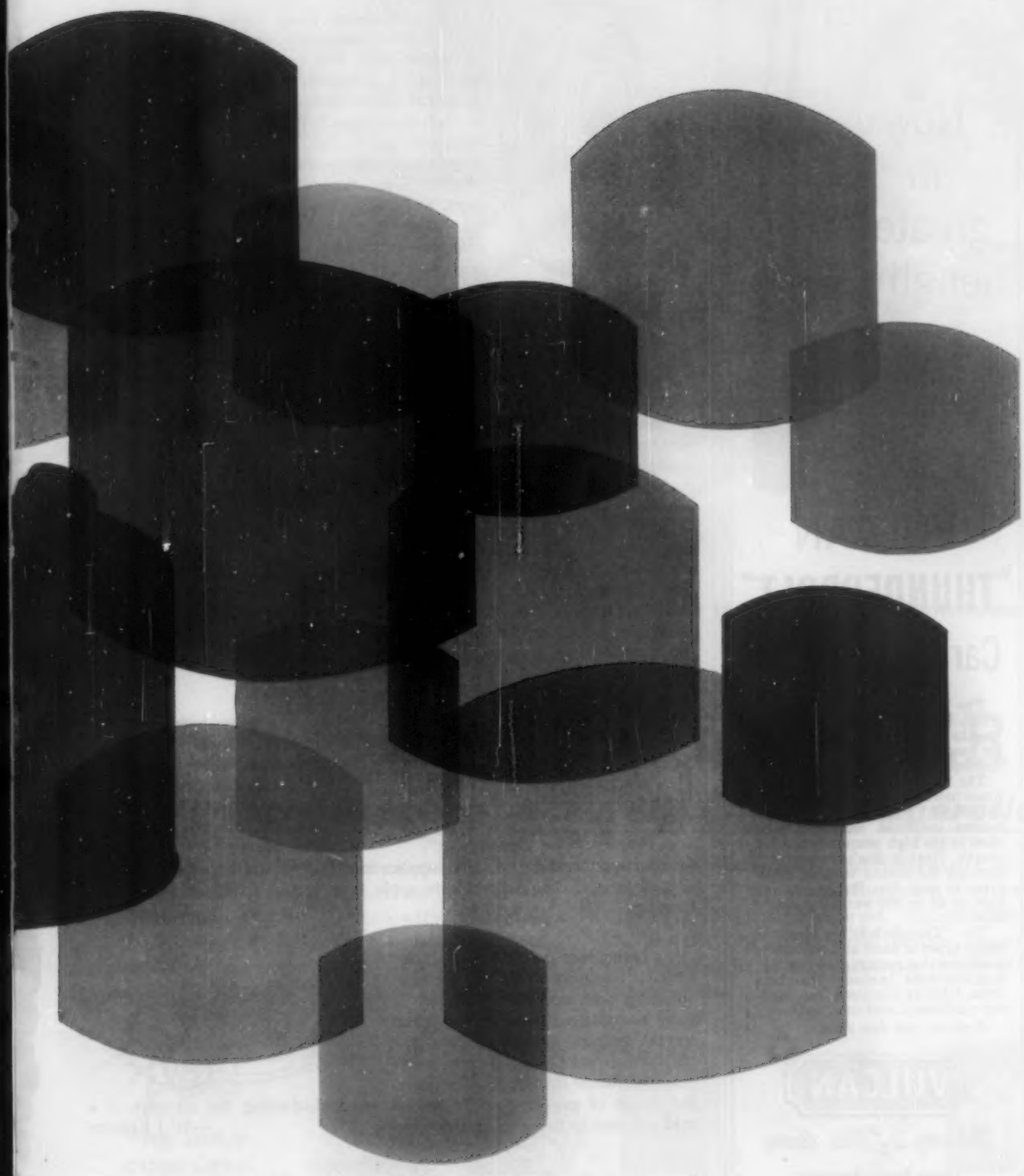
Better products through better methods and steels

How zinc-coated steels make faultless containers with less fabricating

The container shown here is the modern version of the old-fashioned gasoline-oil can—formerly produced with lock or welded seams, then hot zinc dipped for corrosion protection. Its seams collected grease, dirt and moisture and it was susceptible to leakage.
Now—because of Weirkote continuous-process zinc-coated steel—it has a smooth, seamless dome-shaped body, formed in a tortuous three-draw operation. Because Weirkote can be worked to the limits of the steel itself without chipping or flaking, the zinc coating remains intact and further processing for corrosion resistance is unnecessary.
Because side and top seams have been eliminated and the bottom is double-seamed to the body, the container stays cleaner, lasts longer and is leak-proof. Weirkote continuous-process zinc-coated steel is but one of many fine steels produced by Weirton Steel Company—improving products, methods and profits throughout industry.

WEIRTON STEEL COMPANY

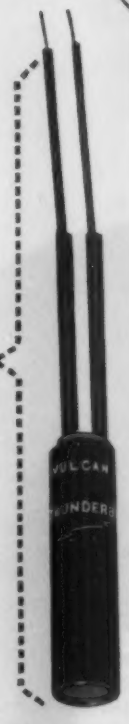
WEIRTON STEEL
Weirton, West Virginia



Weirton Steel is a division of **NATIONAL STEEL CORPORATION**

CIRCLE 31 ON READER SERVICE CARD 31

Now in greater lengths



VULCAN
"THUNDERBOLT"
Cartridge Heater

The Vulcan "Thunderbolt" Cartridge Heater is now available in lengths from 1¼" up to 24 inches (or even *longer*) in ⅜", ½" or ⅝" diameters.

The "Thunderbolt" delivers five times more heat than conventional cartridges. Special construction locates insulated resistance wire close to the high temperature alloy sheath. Heat is dissipated rapidly through the sheath without detriment to unit life. Ratings are as high as 40 to 200 watts *per square inch.*

The "Thunderbolt" is ideal for many types of hand and automatic machines that require spot heating. Applications include branding irons, labeling machines, box making machinery, and many others.

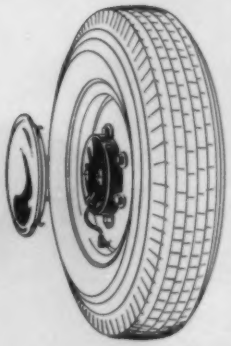
Write for new data sheet.

VULCAN

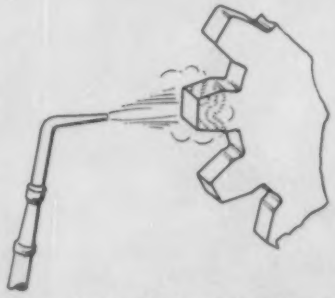
Versatility in Electric Heating

Vulcan Electric Company,
Danvers, Mass.

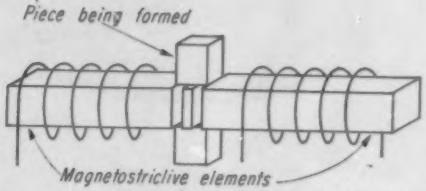
WHY DON'T THEY R&D..?



. . . a small, cheap, pump bolted to each wheel of a car. It would connect to tire valve (core removed) via rubber hose, and operate whenever wheel was spinning. A pressure-sensing regulator would valve air to tire when pressure was low and bleed off air if road heat caused pressure to exceed set, but adjustable, limit. Hubcaps would hide pump but wheel would need counterbalancing with lead weights to offset pump. Pump could be quite crude—it only needs to deliver a small amount of air at about 40 psi. A tire with a slow leak would stay up to pressure when car was moving, and flats could be inflated by spinning them on jacked-up rear wheel.—R MARIE



. . . a simple process for locally hardening low-carbon steel with an acetylene torch. In building or repairing machine tools, it is often desirable to have one or two faces of a part hard without resorting to a lengthy nitriding or case-hardening operation. Facing with hard-facing welding rod requires remachining. Chrome plating or insertion of carbide wear plates is also a lengthy process. But perhaps, with a gas-rich acetylene torch supplying heat and carbon, a catalyst could be developed that would give local surface hardening. Advantages over full hardening: (1) less time and handling, (2) less distortion of detail remote from wear surface, (3) some areas of part machinable. Advantages over hard-facing: (1) no pits, (2) more precise shaping of small parts. —J D THACKREY



. . . a magnetostrictive cold-forging machine. With shorter stroke and higher frequency, it would seem to have an advantage over rotary swaging machines. The magnetostrictive principle has been successful for ultrasonic welding and other applications that require large pressures over a small area; it should be able to apply large enough loads for forging and forming. R A SCHULTZ

. . . a lawnmower powered by a storage battery. For normal use, 30 minutes' operating time would be adequate. It could be recharged from 110-volt house current, properly transformed and rectified, when not in use. Battery power would eliminate starting problem, noise and fumes of gasoline-powered mower while eliminating the nuisance of a cord attached to the usual electric mower. —W J KERWIN

Have you a problem, based on known scientific principles, which seems to have an answer somewhere within the limits of present technology? To inspire inventors along worthwhile paths, PRODUCT ENGINEERING invites you to trade such problems with fellow readers who have a fresh viewpoint or more time to experiment. We pay $10 for each one accepted.

For Your Power Drive • Design • Application or Replacement Maintenance

There's a T-J CYLINDER

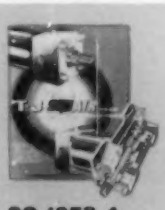
That Can Assure *Accurate Efficient Operation*

Only T-J's complete line can assure you a cylinder of either air or hydraulic application – with practically limitless design specifications for bore, stroke, pressure range and even delivery requirement. From the time-tested, standard tie-rod air and hydraulic, to the exclusive T-J Spacemaker, and including the recently introduced Squair Head, T-J cylinders give you more features for efficient, long-lasting operation. Write today!

Plus

THE ONLY COMPLETE ENGINEERING CATALOG LINE, TOO!

H-47 for standard tie-rod hydraulic cylinders.



SQ-1058-4 for the T-J Squair Head cylinder.

No. 54 for standard tie-rod air cylinders.

SM-56-3 for the incomparable Spacemaker cylinder.

HSM5-56-4 for the High-Pressure Hydraulic Spacemaker cylinder.

THE TOMKINS • JOHNSON CO. JACKSON, MICH.

CYLINDERS • MILLING CUTTERS • RIVETERS and CLINCHERS

Customers rise to the

FISHERMEN!
We'll be glad to mail you names and addresses of over 60 manufacturers of lures made of Tenite Butyrate.

colorful lure of Tenite plastics

■ *To sell a product once, make it attractive.* ■ *To sell a product over and over, make it dependable.* ■ *To make products that are both attractive and dependable, make them of tough Tenite plastic.*

The fish lures shown here are a good example of how the properties of the versatile Tenite plastics can be matched to the demands of a specific application. Made of Tenite Butyrate, these lightweight lures have a buoyancy that permits them to dart and wiggle through the water with graceful, realistic vigor. Yet not even the most savage jaws will break them, so tough is the plastic. Moreover, the plastic bodies undergo little change in salt or fresh water, since Butyrate resists water absorption and neither rusts nor corrodes. Color effects, too, are lasting...for they're applied with durable lacquers that form an integral bond with the plastic.

Is Tenite Butyrate or some other Tenite plastic a possible answer to one of your own material problems? Easy and economical to injection mold or extrude, these Eastman plastics are available in clear transparent or in any color you desire... transparent, translucent, opaque, pearlescent or variegated. Versatile Eastman plastics include Tenite Butyrate, Tenite Acetate, Tenite Propionate, Tenite Polyethylene and Tenite Polypropylene. EASTMAN CHEMICAL PRODUCTS, INC., subsidiary of Eastman Kodak Company, KINGSPORT, TENNESSEE.

TENITE®

BUTYRATE • PROPIONATE
ACETATE • POLYETHYLENE
POLYPROPYLENE

plastics by Eastman

PROJECT 70,000,000

Since their introduction more than ten years ago, CLARE Type J Relays, with their small size, twin contact design and superior performance, have been first choice of design engineers for applications where component failure is intolerable.

Sensational demand for these relays has resulted in numerous imitations. Similar in appearance and published specifications, many have been represented as "just as good" as the original CLARE Type J Relays.

An independent laboratory has just completed exhaustive tests of CLARE Type J Relays and copies made by other well known manufacturers.

The results are here. Tests of the CLARE relays were discontinued at 70,000,000 cycles . . . *with no contact failure whatsoever.* All the other relay groups showed failure of 10% of their contacts before the end of 60,000,000 cycles (see graph). Some had 22% contact failure at 5,000,000 cycles.

Let us tell you more about this important test. Call or write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, P. O. Box 134, Downsview, Ontario. Cable Address: CLARELAY.

CLARE RELAYS

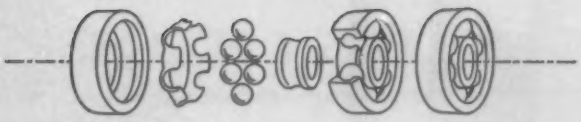
FIRST in the industrial field

Independent tests* prove There are no copies "just as good" as CLARE type J RELAYS

CLARE RELAYS (8 Form C)	70,000,000 Operations No Contact Failures
BRAND X1 (8 Form C)	60,000,000 Operations 11 Contact Failures
BRAND X2 (8 Form C)	40,000,000 Operations 12 Contact Failures
BRAND X3 (8 Form C)	30,000,000 Operations 8 Contact Failures
BRAND X4 (8 Form C)	20,000,000 Operations 12 Contact Failures
BRAND X5 (6 Form C)	15,000,000 Operations 7 Contact Failures
BRAND X6 (6 Form C)	10,000,000 Operations 11 Contact Failures
BRAND X7 (8 Form C)	5,000,000 Operations 18 Contact Failures

*Failure of 10% of the total contacts involved eliminated any group from the test. Additional data available on request.

CIRCLE 36 ON READER SERVICE CARD



MEASURING ROUNDNESS OF INSTRUMENT BALL BEARINGS

By **RICHARD E. AMIDON**, *Staff Engineer, Production Engineering Department*
New Hampshire Ball Bearings, Inc.

Roundness of instrument ball bearings is a variable not covered by ABEC standards. Yet, it is an important factor in running quality. Since it is a very difficult variable to measure, except with costly equipment, most users must accept roundness on faith.

Roundness can be defined as "equidistance of all points on a curved surface from a fixed center". To measure roundness of a ball bearing component, therefore, you must establish its center and radius. However, since its center is not accessible as a point of reference, you must establish an "artificial" center. The closer the assumed or artificial center is to the actual center, the more accurate a given method of roundness measurement will be.

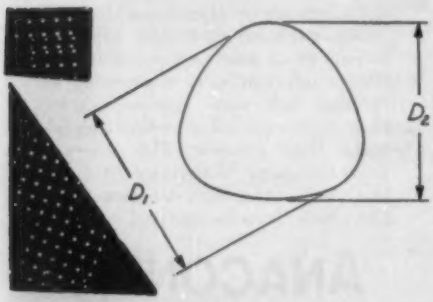
What you're really measuring is out-of-roundness, or deviation from a true circle. Such deviations are called lobing. There are three common ways of measuring out-of-roundness.

THE TWO-POINT METHOD

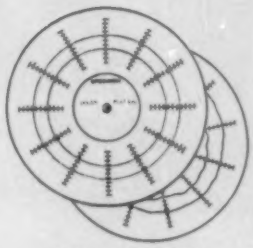
Most widely used of all measuring techniques is the method of measuring various diameters between two anvils as in a micrometer or two-point gage. The difference between the largest and smallest diameter is out-of-roundness. This method is accurate only if there is an even number of lobes of equal height and symmetrical spacing. Notice in the accompanying sketch of a three-lobed shape, all three diameters are equal . . . and the two-point method would indicate perfect roundness.

THE THREE-POINT METHOD

When an odd number of lobes exists, a three-point gage can be used to measure out-of-roundness. Variations are measured by rotating the part between two fixed points at a known angle with each other and a movable point connected to an indicator. This method, which calls for calculations to convert indicator readings to true-out-of-roundness, is accurate only when the number of lobes is known and they are symmetrically spaced and equal in height.



ELECTRONIC GAGING



POLAR CHART TRACE

Fortunately for you, instrumentation has been recently developed which measures out-of-roundness directly as radial variation with accuracy to several millionths of an inch. The part to be measured is chuck-mounted to a precision spindle and slowly rotated. An electronic gage head translates radial surface variations into a polar chart trace with deviations magnified as much as 10,000 times. Comparison of the chart trace with concentric circles of known radii reveals absolute deviation from a true circle. New Hampshire Ball Bearings, Inc. was the first to use this instrument as a quality control tool in the laboratory and on the production line. Other instrumentation used to assure the running quality of New Hampshire Bearings is described in our new Design and Purchasing Manual.

NEW DESIGN MANUAL

Newly revised and expanded, this authoritative publication covers everything you need to know about applying and buying miniature and instrument ball bearings. Comprehensive general information, catalog data and engineering bulletins are included in its 100-plus pages. Personally registered copies are available to qualified engineers, draftsmen and purchasing agents. Please send your request on your company letterhead.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

CIRCLE 37 ON READER SERVICE CARD

THESE BIG TOUGH HOSE ASSEMBLIES SOAK UP THE SHOCK OF A SWING FROM TROPICAL HEAT TO −303°F IN SECONDS

It takes many heavy-duty flexible metal hose connections to feed liquid oxygen to a missile. In the photo above are four 3½" I.D. metal hose lines of stainless steel manufactured by Anaconda Metal Hose. They connect three tank trucks to the pumping station which fuels Jupiters at the Army's Redstone Arsenal. Similar hoses are used to make connections between the fueling masts and the missile itself, making it unnecessary to align piping precisely. As fuel masts are kicked off the missile at firing, the hose must be able to withstand rough treatment and hot exhaust gases, as well as the wide temperature fluctuations.

FREE TECHNICAL SERVICE. Whether you need big, heavy-duty flexible metal connectors for big, tough jobs or small-diameter flexible metal hose for small, tough jobs, Anaconda Metal Hose Division welcomes the opportunity to help you meet your problems of expansion and contraction, movement, vibration, corrosion, pressures, and temperatures. Equipped to work in stainless steel, Monel, and aluminum as well as other alloy steels and copper alloys, Anaconda specialists are constantly working with design engineers on flexible connector assemblies to meet new problems. For further information or engineering assistance, call your Anaconda Metal Hose representative or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 59131

CIRCLE 38 ON READER SERVICE CARD

ANACONDA®
METAL HOSE

PRODUCT ENGINEERING HORIZONS

how to be LAZY

A youngster named Humphrey Potter was hired in 1713 to pull the levers that moved the slide valve on an early steam engine. One lever shut off the steam and let in condensing water when the piston reached the top of its stroke, the other shut off the water and let in steam at the bottom.

The story goes that it was spring and Humphrey had a date with a trout. He noticed that the walking beam and his shifting of levers seemed to work together. So he tried a physical tie-up with some of his fishline to the ends of the beam and the levers—and invented the first valve gear. *Then* he went fishing.

Humphrey was lazy, so lazy that he figured out a way to abandon his job, not just to reduce or delay it. He knew that the really lazy man never procrastinates; he gets the job done on a sensible basis so he has undisturbed loafing time.

Edward Young, more than two centuries ago, wrote "Procrastination is the thief of time." It steals more than that; it also steals our self-respect, our fun, even complete realization of our ambitions.

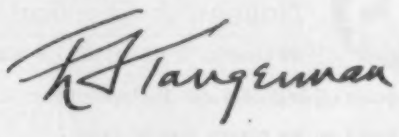
Why? Because we postpone the dirty job, the onerous chore. Any excuse will do: we'll "think about it," or "tomorrow is another day," or we're "too busy"—with trifles. Then, when we're forced to do the job at the last minute, we blunder. By "taking things easy," we make things hard—and spend more energy doing it. Everything is in a constant sweat, which affects not only ourselves but also the others who are inconvenienced by us. And meanwhile, our consciences have been hurting us.

"Putting off the evil day" has a way of creeping up on a man. Darwin was scooped by a scientist half a world away because he postponed publication of his theories. Scientists and engineers have repeatedly been scooped on new ideas and new products because they postponed the last few steps, of development. They took extra time to "think things through" or to "work out the bugs"—and spent the time procrastinating.

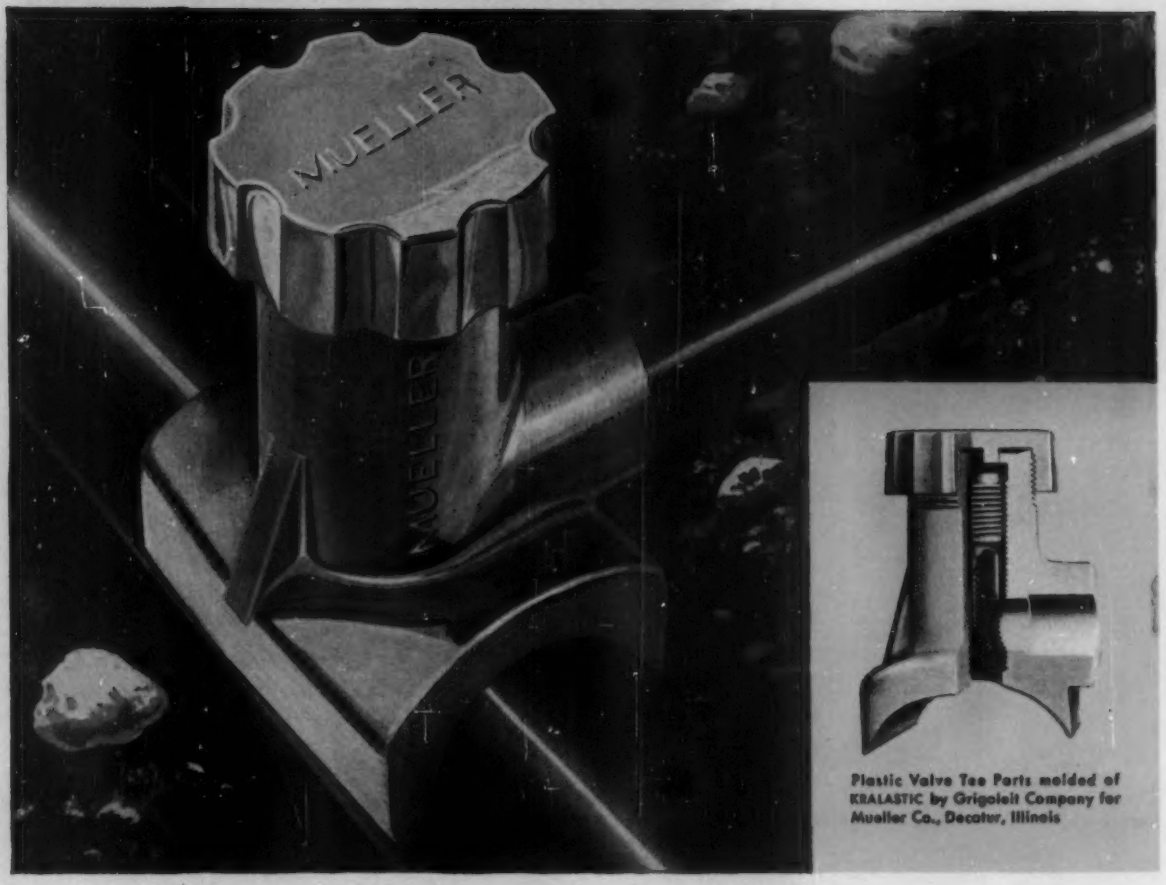
There's an old Indian saying: "The way to cross a river is to cross the river." In other words, don't waste time worrying about whether the water will go up or down, or whether there's a ford a couple of miles away—**start to cross.**

This is fundamental in any creative activity. Writers find their hardest job is to feed a sheet of paper into the typewriter, painters fight to keep from picking up a brush, inventors fight their feeling that they'll do better in a day or two, that they haven't some needed tool. Lord Chesterfield said of the aging Duke of Newcastle: "His Grace loses an hour in the morning, and is looking for it the rest of the day." In our own day, Dr Helen Brandon, the psychological counsellor, found that she spent 120 hours a month waiting for something or somebody—1440 hours a year. Said she: "During this time I thought of 1000 article-ideas, worked on the case histories of more than 100 people, and spent at least one-third of the time relaxing in one way or another."

She "wasted" a third of the found time—but utilized two-thirds of it to advantage. Come to think of it, that's a fairly high efficiency—67%—and it should make the "lazy" 33% really enjoyable.



Naugatuck KRALASTIC®



Plastic Valve Tee Parts molded of KRALASTIC by Grigoleit Company for Mueller Co., Decatur, Illinois

KRALASTIC valve tee now makes safe connections under pressure!

This new Mueller valve tee reflects a careful and intelligent application of material and design...not the least sign of which is the use of KRALASTIC for the tee body, cap and plug. (Pilot screw and cutter are of stainless steel.)

KRALASTIC is the unique rubber-resin blend that has proved so outstandingly successful in oil, gas, water, and chemical pipe and fittings that more than 9,000 miles of KRALASTIC systems are already in use. And here in this valve tee KRALASTIC has particular advantages, beyond the fact that it forms a perfect mate to the many miles of KRALASTIC in gas mains.

Because the unit contains a built-in cutter to permit tapping a plastic main under pressure, strength and dimensional stability are of unusual importance. And the use of clamps and drilling tools for installation adds further to the need for toughness, a feature in which KRALASTIC is exceptional.

Look for KRALASTIC not only in pipe and fittings, but in tool handles, machine housings...any place where toughness, strength, light weight, dimensional stability and freedom from corrosion are an asset. For more information on KRALASTIC pipe and fittings, or on KRALASTIC for other applications, write us today.

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Design rules for that new process . . .

SPRAYED REINFORCED PLASTICS

In the two highly competitive years since it was introduced (see PE—Jan 18 '58, p 17), spray-up has become an economical process for making large parts from fiberglass-reinforced plastic. And it's bidding to produce smaller FRP parts too.

DEWEY ELDRED, *manager, Technical Service Dept, Rand Development Corp*

WHAT IS SPRAY-UP?

Spray-up was developed to overcome the major limitations of the hand lay-up process. It dispenses with glass mat or cloth. Instead, roving is drawn from a creel, fed through a chopper and blown at the mold. Resin-system ingredients are injected into the glass stream by either of two basic spray guns: first employs two metering nozzles—one carrying resin premixed with catalyst, the other carrying resin premixed with accelerator; in the second gun, designed for epoxies, ingredients are fed separately into a mixing chamber just ahead of a single spray nozzle. By either method, resin mix coats the glass strands, and the merged spray is directed evenly into the mold by the operator. Glass-resin mass thus applied is then rolled out by hand to remove air and pack the mix to uniform thickness. Curing is the final step.

Of all the recent additions to the family of fabricating processes (*PE*—Jan 11 '60, p 47) for fiberglass-reinforced plastics, the spray-up method requires the greatest change in design thinking. This is because the operator of the spray gun controls the way in which the mixture of catalyzed resin and chopped glass is laid down in the mold. Since experience has shown that trained operators can direct the mixture precisely where needed, you can economically specify these features in design:

- Tapered wall sections and built-up radii that distribute stresses efficiently.
- Different glass/resin ratios within the same part, where needed in high-stress areas.
- Embedded fittings of wood, plastic and metal for local stiffening, or coupling to other structures.
- Large areas of sandwich construction (using foamed plastic cores) for vibration damping, stiffening, or thermal insulation.

text continued on page 43

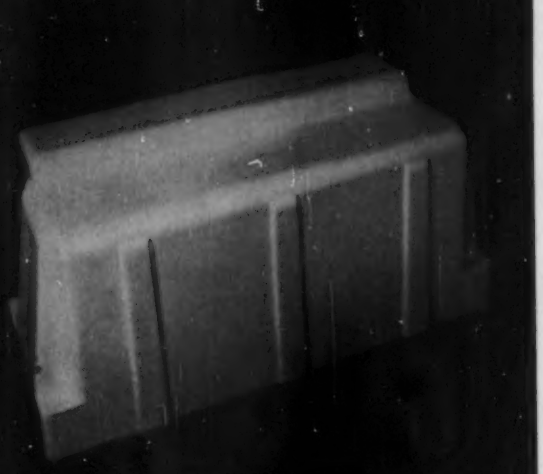
TYPICAL JOBS

Large parts

TRUCK ROOF for ice cream van has 2 in of foamed styrene insulation, weighs 180 lb compared with 580 lb for the uninsulated, metal-wood roof. Stiffeners are also made by Spray-up. Process cut $20 off cost of roof. For details of sandwich construction, see photo, last page.

SPHERICAL TANK that resists corrosive liquids is ideal part for Spray-up because of its large size and simple shape. Unique dies help keep cost down: tank is made in two 12-ft-dia hemispheres, each sprayed over inflated, vinyl-covered bag. Bag rotates slowly as operator lays down 3/10-in. layer. Final joint also made by Spray-up. Tank holds 6770 gallons.

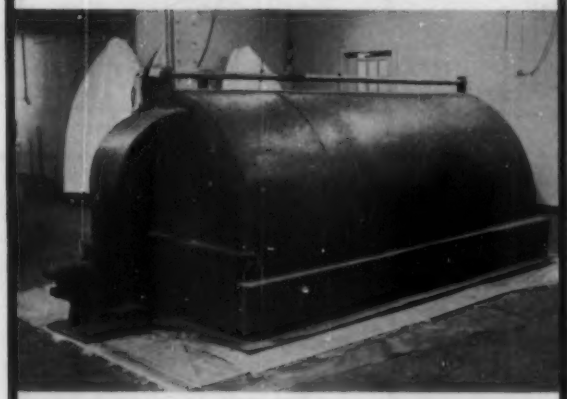
Small parts



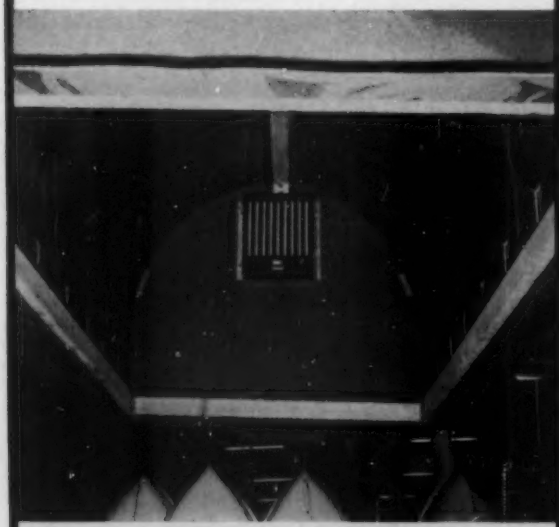
HIGH-VOLTAGE MAGNET-COIL HOUSING has surface finish and shape complexity comparing favorably with parts made in matched metal molds. Good surface finish results from three factors: choosing a resin that clings well to FRP mold, working the resin into the mold surface, and adding a good wetting agent to the mix. Housing is 32 x 12 x 8 in, weighs about 10 lb.

HOUSING FOR DRIVE MECHANISM of boom on repair truck is designed in three parts, one of which is shown here. Note fairly sharp radii, small size and complicated shape. Parts like this (and coil housing above) are best made with a fairly narrow spray so that resin-glass mix will not bridge and thickness control can be maintained. Color is added directly to resin here.

One-shot structures



CURING OVEN for small boat hulls, shown here in two views, illustrates how Spray-up can do one-of-a-kind jobs quickly and cheaply. A frame for 2 x 4's and hardboard was constructed in less than 4 man-hours. This shell was sprayed with about ⅛ in of glass-resin mix. After main shell was cured, return-air ducts along bottom edge were formed from cardboard, tacked in place with masking tape, and sprayed to form an integral part of oven. Air delivery elbow was similarly constructed. Cutting slots in bottom duct for return air, and rectangular hole for bank of strip heaters, completed the structure. Squirrel-cage blower and 12-kw heaters maintain oven at 150 F, with only 8° variation throughout.



- Unusual contours that would be prohibitively expensive to cut in metal dies.
- Spray-joining of FRP parts too large or complex to be made in a single assembly.
- Coatings on metal parts of the structure to prevent corrosion attack.
- Re-entrant corners (reached by shortening fiber length during spray-up).

Other fabrication processes for FRP permit some or all of these design features, but none so economically and naturally as spray-up. In general, spray-up complements conventional processes, like air preform-matched metal-die molding, and is their strongest competitor under these conditions: when large and complex shapes weigh 50 lb or more, and are turned out in low-production runs of about 1000 parts per month maximum, or when prototype parts are needed.

Like all general rules, this one has its exceptions. Take minimum weight: parts like the magnet-coil cover in the accompanying photos weigh as low as 10 lb. Because of glass bridging, the smallest box-shaped part possible would be a 1-ft cube. Or consider production rate: this depends on size and complexity of the part, as well as on spray-up facilities available. Some molders have but one gun, others have as many as 12 guns—and 5000-gal. underground tanks supplying the resin.

Spray-up is a good way to try fiberglass-reinforced plastics without too deep a commitment, an advantage that conventional processes seldom offer. How this works, and how other processes like matched metal molding tie in, is illustrated by the following typical sequence:

A metal part is found suitable for FRP and for spray-up; an inexpensive wooden pattern is constructed and an FRP mold is made over it via spray-up; with this mold, prototype parts are made by spray-up; after successfully testing the prototype, the part is formally converted to FRP and production is begun a few new FRP molds may be needed); if very high production is needed, the part can shift from spray-up to matched metal-die molding—very often at the same unit price, with the difference in production cost going toward die amortization.

Successful exploitation of spray-up in this manner depends on accurately estimating the possibilities for the process by checking these questions:

(1) Does the part have to be made in its present shape? It's surprising how many metal assemblies can be reduced to a single FRP part—thus eliminating costly assembly steps.

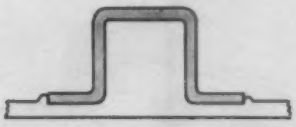
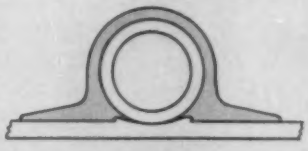
(2) Has the part been redesigned to its simplest form? By studying the function of each metal component—brackets, fasteners, stiffeners, stops, baffles, etc.—you can often combine functions, eliminate others, and get an optimum shape for spray-up.

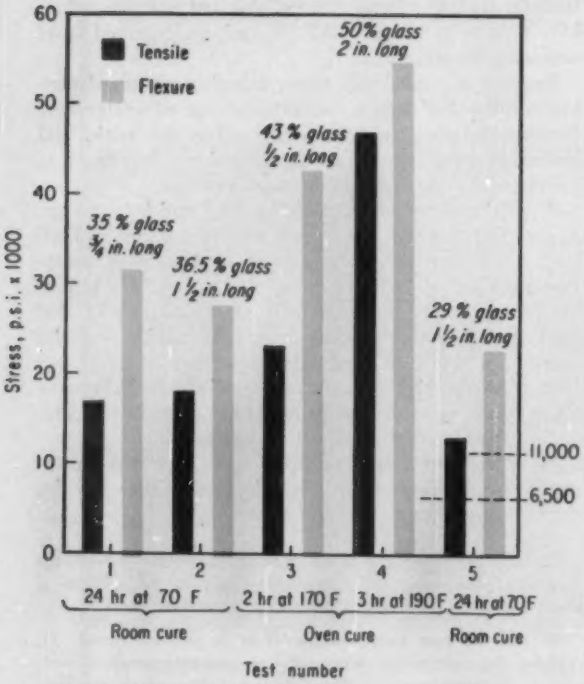
(3) Can the part be made in combination with one or more other parts being separately fabricated? Generally, large parts are best suited for spray-up. Combining parts has long been a key advantage of FRP, and spray-up—with its hand-directed application of material—accentuates this advantage.

(4) Are the properties of FRP required in this application? The main properties helpful in design are these: a good strength-

REINFORCEMENT AND ATTACHMENT

Reinforcements

Encased Stiffeners	Separate Stiffeners	Integral Stiffeners
		
Wood, plywood and metal angles are most often employed. Stiffener is pressed firmly into sprayed-up layer while it is still wet, then covered with a coating of mix to anchor it firmly and protect it from deterioration. Reinforcement is supplied by both embedment and its coating.	By constructing separate molds, Spray-up can be used to fabricate stiffeners from FRP. These are then pressed into the layer to be reinforced while it is still wet, as shown with the "hat" shape above. Since polyester will adhere well to itself, extra layer over flange is not needed in most instances.	These are formed by spraying over light, low-cost forms pressed into the wet layer. Forms can be simple cardboard mailing tubes (shown here), folded cardboard, bent screen or balsa wood. Stiffening is achieved solely from geometry of sprayed-up FRP as determined by form.



MECHANICAL PROPERTIES of spray-up FRP vary with glass content, operator skill, degree of cure,—as these test values show. Tests 1 through 4 are for laboratory samples; Test 5 shows average values for production parts. Dashed lines are suggested values for conservative design. Note that glass contents up to 50% hold promise for substantial improvement in properties. Glass finish on all tests was hard chrome. Silane finishes are used too, but require control of static electricity to prevent fiber "hangup."

weight ratio, excellent corrosion resistance, translucency, favorable dielectric properties, and good impact strength.

(5) Can cheaper materials be selected? There is no need to buy fiberglass-reinforced plastics for the entire part, when it may be needed only for a coating or for strengthening a part.

(6) What is reasonable price for the part? FRP may be a deluxe material in this application; there is no need to buy quality that cannot be sold.

Spray-up FRP Properties

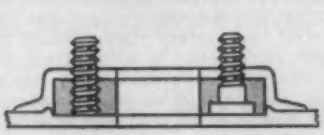
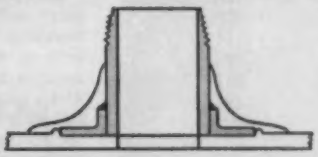
If the answers to these questions, when analyzed, indicate the part is suitable for spray-up, stress analysis is the next problem. Fiberglass-reinforced plastic by spray-up, correctly laid down, is essentially isotropic. However, a suitable design stress must be chosen. Tensile and flexure strengths from spray-up parts in production are somewhat lower than those for laboratory samples (see bar chart). What the average trained operator can produce is the controlling factor. Thus a maximum flexure strength of about 22,000 psi, and a maximum tensile strength of 13,000 psi, are realistic. Using a safety factor of 2, design stresses then become 11,000 psi and 6,500 psi, respectively. Increasing the glass content and adding a post-cure step can raise these figures, in production, by about 50%.

Glass content clearly controls properties, but the process is limited, so far, to about 35% max glass in production situations. Glass concentrations up to 50-55% have been achieved in certain applications. Wetting the glass properly is the problem here. Proper wetting is difficult to achieve in the roll-out step. Most production molders prefer approximately 29% glass to get ample resin for wetting, giving good bond in all sections of the part.

Thickness Considerations

Thickness control is a major problem, as it is with the air preform process when directed-fiber technique is employed. Success depends on operator skill. Experience has shown, so far, that thicknesses from ⅛ in. to 1 in. can be

METHODS FOR SPRAY-UP FRP

	Attachments		
	Bolting Flange	**Threaded Coupling**	**Nailing Insert**
			
	A circular ring is cut from a layer of previously sprayed-up FRP about ½ in thick. Tapped for threaded studs or drilled and countersunk for cap screws (both shown here), this ring, with fasteners in place, is pressed into freshly sprayed layer. Cover layer can be added for extra strength. For studs, threads are precoated with resin; for cap screws, tight pressfit is specified. Hole in bottom layer is cut last.	This method uses a collar of expanded metal mesh (or coarse screen) tack-welded to a threaded pipe coupling. Metal assembly is pressed into wet Spray-up layer and a cover layer is added for increased torque-resistance. Large beads on tack welds should be specified to act as keys against twisting.	By designing a depression into the Spray-up part, an epoxy resin can be cast in place which is suitable for nailing or other mechanical fastener. Positive surface of mold required to form the depression is purposely left rough to give maximum gripping with epoxy insert. One suitable epoxy casting resin is Maraset No. 611, made by Marblette Corp.

laid down. Thickness tolerances cannot be held as closely as with matched metal-die molding. Good spray-up production tolerances for the common ⅛-in. thickness are: +$\frac{1}{64}$ in., −$\frac{1}{64}$ in.

Heavy thicknesses are built up by successive layers of mix, rolled out in turn. Experience has shown that glass distribution within each layer can be quite uniform, and that multiple layers—when cured—produce a homogeneous mass. When a higher glass/resin ratio is needed in a certain area, the gun can be adjusted during spray-up. Variations in thickness are achieved by simply applying lighter or heavier deposits where needed.

These techniques are advantages over hand lay-up laminating methods which require buildup of final thickness by multiple layers of glass cloth or mat, along with careful tapering and fitting to give thickness variations. One caution here, however: Although spray-up avoids delamination possibilities inherent in hand lay-up, it gives lower glass content and hence lower strength.

Materials

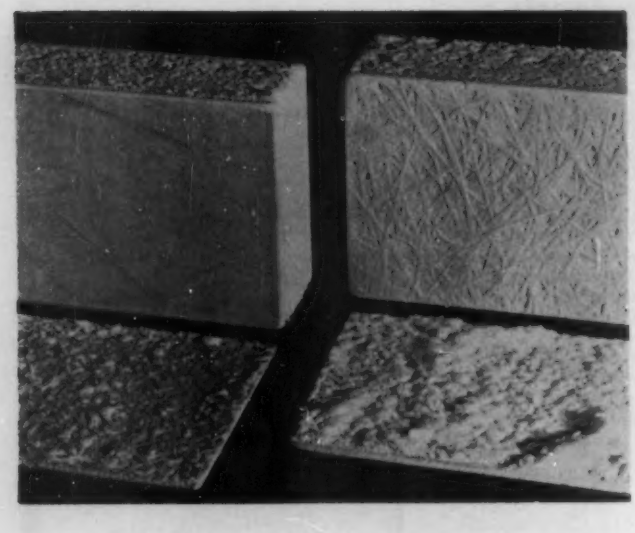
Resins used with spray-up are thixotropic enough to allow vertical thicknesses up to about ½ in. to be sprayed. Mix can be sprayed into the mold and rolled out faster in the down-hand position, the reason why molds are often rotated so as to present a nearly horizontal plane to the operator. Polyester resins shrink during cure, therefore, 1° min draft, or more, is necessary to give quick breakaway—especially on male molds. Release agents like wax, polyvinyl alcohol (PVA) and silicones are needed.

Choice of polyester resin for a spray-up part is usually left to the molder. Many resins are available and most produce nearly identical mechanical properties. One is chosen over another for reasons more related to cost, chemical resistance and handleability than to design. Flame resistance (see *PE*—Aug 3 '59, p 38) is one feature the designer can specify and get easily, and is an important plus value in most industrial applications. Specially compounded polyesters that surpass white oak in self-extinguishing characteristics are readily available at very slight cost premium. Additions of antimony trioxide and other compounds to these resins make them even more self-extinguishing—close to asbestos, in some cases. Some flame-retardant polyesters retain translucency, and so work well with spray-up; additives tend to make the mix opaque. Use of these resins in spray-up applications is growing. Epoxies can also be used, with special guns designed to overcome short pot-life problems associated with these resins.

Glass used in spray-up is in roving form—coated with organic chromium or silane compounds for better bond, and chopped in the gun to lengths from ½ in. to 4 in. long. Some molders remove the chopping blades and spray continuous roving to get increased strength—a technique that requires somewhat simpler shapes. Fillers can also be introduced into the glass stream, lowering the glass content and thus the cost (as well as strength), or imparting unusual properties to the laminate.

Design Details

Local reinforcement, assembly aids, and openings are three major design problems with any FRP structure. Many of the techniques developed for established fabrication processes also apply to spray-up. The accompanying table gives six techniques, for reinforcing and joining, shown from experience to be particularly effective with spray-up. Note, though, that increasing part thickness is often cheaper than local reinforcing, since spray-up process need not be interrupted. On openings, the most common and economical procedure is to specify sawing or punching after curing. An alternate technique is to knife-cut the opening when the part is partially set, when the mix has the consistency of Swiss cheese. Occasionally molds are



SANDWICH CONSTRUCTION is easily built into parts with Spray-up. Sections shown here are from insulated truck roof. Piece at left shows smooth surface of first FRP skin, achieved by spraying into smooth mold. Styrene foam core is then sprayed with rubber-base contact-type structural adhesive, and pressed onto cured skin. Second skin is sprayed-up against foam plastic core, giving rough surface as shown in piece at right. This roughness is characteristic of all Spray-up parts on the side away from the mold. Some styrene foams will resist attack by polyester resin when this second skin layer is applied; others require an inhibiting barrier sprayed on first. Either way, the second interface is much stronger than first interface, as shown by peeled-off skins in foreground. Note that second interface (right) held, with failure in core—but that first interface failed in adhesive as shown by bare spots.

specially cored to form holes during spray-up, but this can be expensive.

What's Coming?

Along with intensive development of the spray-up equipment itself, to make it simpler and cheaper to operate, such developments as these are underway:

New materials. Other fibers besides glass—synthetics like nylon and Dacron, inorganics like asbestos and graphite—as well as various low-cost fillers, are being tried with promising results. On the resin side, lower-cost high-molecular weight polyesters are becoming commercially available. Spray-up parts with these resins will have improved chemical resistance, wet strength, and creep resistance.

High-speed production. One problem so far is the low use factor on spray-up guns. Efforts to make the process a more continuous one, thus lowering costs, include multi-station setups with many molds, and new resin-catalyst handling systems that give automatic adjustment to ambient temperatures from 60-100 F. Heretofore, such temperature changes have required an adjustment to the resin-catalyst system.

Mold releases. New parting techniques for spray-up are being developed which will give: lower part cost through lower mold preparation time (where most labor cost now is); better surface finish on the part; faster release; and the possibility of masking for two-tone color spraying—currently of interest to boat hull manufacturers.

Larger structures. Air-inflated fabric molds (see pg. 42) have shown that large structures like tanks, quonset huts and equipment shelters are simply made by spray-up. Development here continues.

Process integration. Spray-up may substitute for established methods of making preforms by spraying directly into matched metal molds. An alternate technique under study sprays glass-resin mix over a low-cost dry preform made like an egg-box from paper pulp. The coated preform would then be inserted into match dies and the part cured in conventional manner. Main drawback to this type of process integration is the present capital investment for existing preforming methods.

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EDITOR'S NOTE: This is the third in our continuing series of detailed articles on the seven basic processes for fabricating fiberglass-reinforced plastic parts. The first two articles in the series, and a special report that identifies and compares all seven processes, are listed below:

Choose the Right Process for Fiberglass-reinforced Plastics, Jan 11 '60, p 47—Special report selects 7 key processes out of the 15 available, explains their strong and weak points, and shows how one or the other becomes the logical choice in most commercial-volume applications.

Design Must Be Different for Polyester Premix Molded Parts, Oct 12 '59, p 76—They can take the place of metals in many applications, but design follows different rules than for unreinforced plastic molded parts.

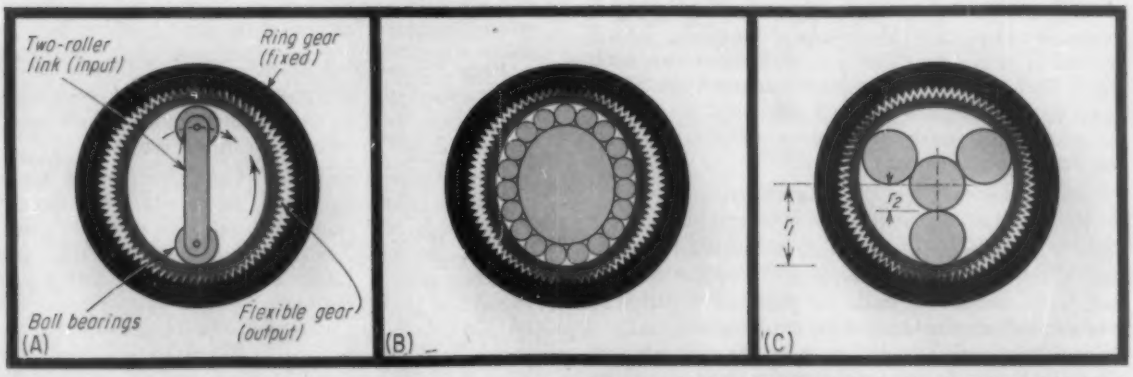
Filament Winding Grows Up, July 20 '59, p 46—After several successful years in the aircraft industry, this high-speed process is ready for more work. Article gives rules for design.

Parts shown in the pictures accompanying this article on spray-up were made by Fiberglass Products Engineering Co, Norwalk, Conn—whose shop facilities appear on the first page. The tank and curing oven were produced by Rand Development Corp., Cleveland, Ohio.

the Harmonic Drive . . .

INNOVATION IN HIGH-RATIO GEARING

The novelty here: a not-quite-large-enough but flexible ring gear that rolls at a slow pace inside a fixed ring gear. **Result:** high-torque, high-reduction speed variations. Here's a rundown on advantages of this drive; equations relating its torques, stresses and efficiencies; and a table comparing it with four conventional gear systems.



THREE VERSIONS OF DRIVE. Flexible gear is deflected in (A) by two-roller link; (B) by elliptical cam rolling within ballbearings; (C) by planetary-gear system for still-higher speed change.

NICHOLAS CHIRONIS, *associate editor*

The recent announcement by Western Gear Corp that it will produce "Harmonic Drives" for applications in the aircraft field illustrates the rush in the industry to bring out novel mechanical devices for obtaining high-ratio speed variations (see references in "Editor's Note" to such innovations as the planetary friction drive, and the pairing of helical with spur gears to get fantastically high speed-reductions).

But none of the other new gearing ideas takes quite so radical a departure from conventional design . . . in Harmonic Drive one of the gears is constantly changing shape. Since United Shoe Machinery Corp.'s original announcement of this drive (*PE*—Dec 9 '57, p 9), the company has moved cautiously. When it licensed Western Gear to manufacture the drives, it acted only after conducting an extensive survey of potential applications. United Shoe is now planning a public display of the drive at the Design Engineering Show to be held this May at the Coliseum in New York.

Here are some features of the new drive. It is highly efficient. It can step up or step down speed ratios by as much as 1,000,000:1. It can also transmit rotary-to-rotary, rotary-to-linear, or linear-to-linear motion. The basic rotary version is built around only three parts—although to obtain the higher ratios the drive must be multistaged.

Principles of operation, analysis of wave and tooth form, basic relations, design formulas and distinctive features are drawn from Patent No. 2,906,143, issued Sept 29, 1959, to C. Walter Musser and assigned to United Shoe Machinery Co.

Inventor and patentee of the drive is Dr C W Musser, a United Shoe consultant.

How the Drive Works

The rotary version has a ring gear with internal teeth mating with a flexible gear with external teeth—see (A) in previous illustration. These teeth are straight-sided, and both gears have the same circular pitch, hence the areas of engagement are in full mesh. But the flexible inner gear has fewer teeth than the outside gear and therefore its pitch circle is smaller. Third member of the drive is a link with two rollers which rotates within the flexible gear, causing it to mesh with the ring gear progressively at diametrically opposite points. This propagates a traveling strain, or deflection wave in the flexible gear—hence, United Shoe's tradename, Harmonic Drive. If motion of the center link or "wave generator" is clockwise, and the ring gear is held fixed, the flexible gear will rotate (or "roll") counterclockwise at a slower rate, with constant angular velocity.

Teeth are stationary where in mesh, thus acting as splines in full contact. Movement of the flexible, driven member is confined to that area where teeth are disengaged. Each rotation of the center link moves the flexible gear a distance equal to the tooth differential between the two gears. Thus, speed ratio between center link (input) and flexible gear (output) is

$$\frac{V_o}{V_i} = \frac{N_f - N_r}{N_f}$$

where V_o = output velocity, rpm; V_i = input velocity, rpm; N_r = number of teeth (or pitch dia) of the ring gear; N_f = number of teeth (or pitch dia if permitted to take its full circular form) of the flexible gear.

For a drive with, say, 180 teeth in the ring gear and 178 teeth in the flexible gear (for the drive illustrated, difference in the number of teeth must be an even integer), the speed ratio will be

$$\frac{V_o}{V_i} = \frac{178 - 180}{178} = -\frac{1}{89}$$

Negative sign indicates that the input and output move in opposite directions. Actually, any one of the three basic parts can be held fixed and the other two used interchangeably as input and output. If the flexible gear is prevented from rotating, and the ring gear is to produce the output rotation, then.

$$\frac{V_o}{V_i} = \frac{N_r - N_f}{N_r}$$

This is also the equation for a conventional two-gear planetary system (see "Epicyclic Gears for Control Mechanisms," Feb '57, p 194).

Other Basic Forms

Besides the two-roller link, there are other possible configurations for generating a harmonic wave in the flexible gear. In (B) of the illustration on previous page, the inside of the flexible gear acts as the outer race of a ballbearing. The inner race is elliptical and causes the gear teeth to be in full engagement along the major axis of the ellipse. Along the minor axis, the teeth are fully disengaged. This configuration permits higher torques to be transmitted than with a two-roller link because the flexible gear is supported around its entire circumference.

The planetary-roller configuration in (C) permits better balance than with a two-roller link. In addition, the over-all gear ratio is increased by the planetary reduction. If driven by the sun roller, the over-all ratio will be

$$\frac{V_o}{V_i} = \frac{N_f - N_r}{N_f}\left[\frac{r_2}{r_1 + r_2}\right]$$

That ratio, $r_2/(r_1 + r_2)$ can be made to vary for practical purposes from about 1/2.5 to 1/10.

Features Claimed by Inventor

Dr Musser points out that the new drive avoids many characteristic difficulties of the conventional gear systems. Some distinctive features of the new drive are:

Large Percentage of Teeth in Contact. Usually 55% of them are in active engagement. This offers a much higher torque capacity than conventional gearing, which usually has only 2 to 6% of its teeth in full contact.

Large Torque Capabilities. Calculations by Dr Musser indicate a surprisingly large torque-producing capacity. For example, take a drive with pitch dia of driven gear = 4 in.; 2-lobe contact; coefficient of friction = 0.05; gear-reduction ratio of 1/100; and made of steel with a shear strength of 50,000 psi. Output torque capacity here would be 126,000 lb.-in., and tooth-contact pressure for this torque would be less than 22,000 psi. If the input were driven at 1800 rpm, the power output would be 36 hp. But a gear of this size would not have sufficient thermal capacity, even with cooling, to deliver an output of this amount continuously. However, if used for the transmission of 1 hp, it would have an overload or shock-resistance safety factor of 36, as compared with the safety factor—on the order of only 2 or 3—of many conventional gearing systems.

Ratios from 10:1 to 1,000,000:1. For ratios above 200:1 the planetary wave generator will do. For ratios from about 1,000:1 to 1,000,000:1, a dual drive (a drive within a drive) can be employed.

High Mechanical Efficiency. Because of low friction losses a drive with a ratio of 100:1 has an over-all efficiency between 69 and 96%, depending on workmanship and lubrication. Increasing the ratio does not decrease the efficiency as markedly as is the case with standard gearing: a drive with a 400:1 ratio will be 80% efficient.

Adjustable Freedom from Backlash. By making the inner member capable of adjusting the deflection, back-

lash can be removed from a gear system by increasing the deflection to the point where the crest of the wave is radially deflected farther into the mating tooth spaces—until the teeth at each side come into contact.

As in standard gearing, when its center distance is changed, this partly destroys the theoretical tooth relationship. However, in the new drive this does not appear to have a deleterious effect as the angular change from the theoretical parallel mating surfaces is very small. By increasing the deflection, the crest can be made to spring-load the contacting piece. A slight amount of spring-loading eliminates all backlash and preloads the piece to assure freedom from backlash later—when high spots on the teeth wear away. It has been experimentally determined that a Harmonic Drive can be easily made free from all backlash without a marked increase in input torque.

Low Pitch-line Velocity. There are only two gears involved in the entire gear train under normal circumstances, and one of these is stationary with zero pitch-line velocity. The other has a rotational speed equal to that of the output shaft. Since the gear ratios are relatively large in many cases, the output rotational speeds are relatively small, usually of the order of 10 to 100 rpm. With a 4-in.-dia gear this would give a pitch-line velocity of only 100 ft/min.

No Impact Stresses. Tooth motion is sinusoidal. This effectively avoids all shock because the teeth gradually decelerate to zero radial velocity after passing the tooth contact area. They then accelerate in the opposite direction up to the point of tooth engagement. During this engagement they are moving essentially at constant velocity. This action is similar for both ends of the radial tooth travel.

Low Tooth-sliding Velocity. For the drive discussed under torque capabilities, a tooth would move 0.04 in. into and out of engagement for each 180° of rotation, or 0.04 in. radial motion in one quarter-revolution. At 1800 rpm, maximum sliding velocity on the active profile of the tooth would be 27.5 ft/min, as compared with 2500 ft/min for an equivalent epicyclic gear system (see table above).

Uniformly Distributed Wear. Each revolution of the input brings every tooth on each gear into active contact with mating teeth on the other gear several times. This effectively prevents differential wear, particularly in reciprocating use such as on hand-operated controls or instruments. The large percentage of teeth in contact at all times also tends to distribute the wear over all the teeth.

Ease of Lubrication. Low velocity, short travel, and the fact that the teeth move in and out radially, permit an all-stainless steel drive without lubrication (not usually recommended with conventional gears).

Small Size. Calculations indicate that, excluding the question of thermal capacity, the new drive would need less than 10% the cubic space of a standard gear reducer of equivalent ratio and torque capacity..

FIVE GEAR SYSTEMS — A COMPARISON
(all systems producing 1 hp at 18 rpm)

	Epicyclic	Herringbone	Single worm	Helical worm	Harmonic drive
Speed ratio	97.4	96.2	108	100	100
Efficiency, %	85	85	40	78	82
No. of gears	13	4	2	4	2
No. of bearings	17	6	6	6	2
Pitch-line velocity, ft/min.	1,500	1,500	1,500	1,500	18
Tooth-sliding velocity, ft/min.	2,500	2,500	1,500	2,500	28
Tooth-contact pressure, psi	50,000	50,000	5,000	50,000	605
Teeth in contact, %	7	5	2	3	50
Safety factor	3	2	2	2	36
Height, in.	13	14	23	16	6
Length, in.	15	20	19	17	6
Width, in.	13	10	14	10	6
Cubic volume, in.	2,500	2,800	6,100	2,700	216
Weight, lb	246	280	230	205	30
Tooth contact	Line	Line	Line	Line	Surface
Quiet operation	No	Yes	Yes	Yes	Yes
Balanced Forces	Yes	No	No	No	Yes

Ease of Manufacture. Teeth can be broached from tubing in quantity-production lots. Because the gears are essentially rings, there is no center hole to which the teeth can be eccentric. Also, ellipticity or out-of-roundness has no serious effect.

Quiet Operation. It results from adjustable freedom from backlash, large percentage of teeth in contact, low pitchline velocity, small tooth-motion, low tooth-sliding velocity, low tooth-contact pressures.

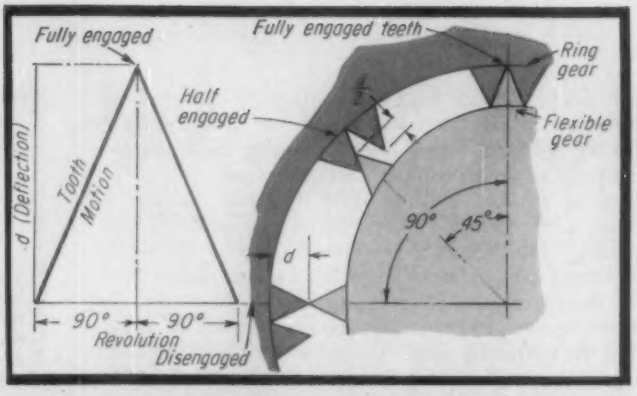
No Load on Bearings. All forces within the system are counterbalanced; consequently the drive can operate without bearings on either the input or output. Forces tend to be self-centering. Several models applied to motors have used this centering tendency as the motor bearing for one end of the armature.

Optimum Tooth Form

Tooth size, shape and differential greatly influence the percentage of teeth which are in engagement. In fact, for properly shaped teeth, 100% of the teeth are in contact, but in various degrees of engagement, as illustrated on next page. Proceeding from base line, which is the disengaged position, one side of the ring-gear teeth will become progressively more engaged with one side of the flexible gear teeth.

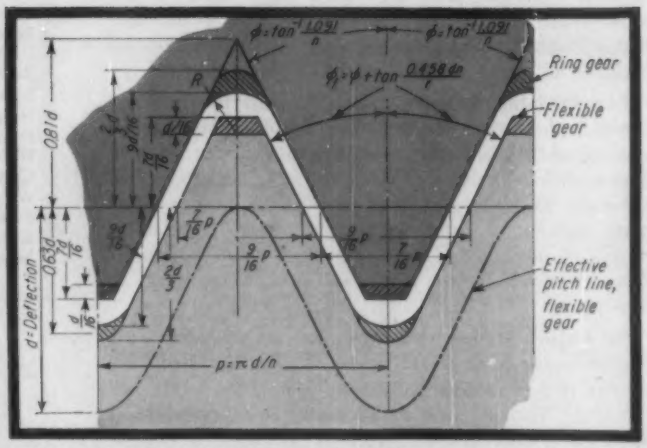
At point of 45° revolution, the teeth will engage 50% of the deflection; at 90° revolution they will be fully engaged. Beyond 90°, the teeth will become progres-

THEORETICAL TOOTH ACTION for two-roller version of drive has 100% of teeth in contact in various degrees of engagement.



SYMBOLS AND RELATIONSHIPS

- a = addendum = $7n/16P$
- b = dedendum = $9n/16P$
- c = clearance = $n/8P$
- d = height of harmonic wave = total radial deflection = n/P
- D_D = pitch dia of driven gear, in.
- D_F = pitch dia of fixed gear, in.
- e_m = mechanical efficiency
- f_1 = coefficient of sliding friction, gear teeth
- f_2 = coefficient of friction between rollers and flexible gear
- F = face width of gear, in.
- n = number of lobes on wave generator (for two roller link = 2, etc.)
- p = circular pitch = $\pi d/n$
- P = diametral pitch = π/p
- R = gear ratio = $D_D/(D_D - D_F)$
- r = pitch radius of ring gear, in.
- S_w = surface endurance limit, psi
- T_i = input torque, in.-lb
- T_o = output torque, in.-lb
- ϕ = pressure angle: ring gear = $\tan^{-1}(1.091/n)$, degrees
- ϕ_f = pressure angle: flexible gear = $\tan^{-1}(1.091/n) + \tan^{-1}(0.458\ dn/r)$



PRACTICAL TOOTH FORM makes allowances for dimensional tolerances and has slightly larger pressure angle for flexible gear than for ring gear. Approximately 55% of teeth are always in engagement, as against 2 to 6% for standard gears.

sively less engaged—here, however, the opposite side of the teeth are in contact. Thus, for the same direction of drive, successively opposite sides of the same tooth engage as the teeth advance.

Results of tests and calculations show that the straight-sided tooth forms, illustrated above, are the most practical. Note that the pressure angle for the flexible gear is slightly greater than for the ring gear. This compensates for the angularity of the flexible gear with the pitch-circle circumference during tooth contact.

Design Formulas

Because interaction between the teeth is dissimilar to that of conventional gearing, standard gear formulas are not applicable. Dr Musser points out that with the Harmonic Drive there is surface contact rather than line contact in the mating teeth; also, teeth cannot be analyzed as cantilever beams because of the pressure-angle relationship to tooth size. Here are the design formulas relating torques, stresses and efficiencies (see list of symbols above):

Output-torque capacity

$$T_o = \frac{\pi r^2 F S_w \cos\phi}{4 \sin\phi}$$

Mechanical efficiency

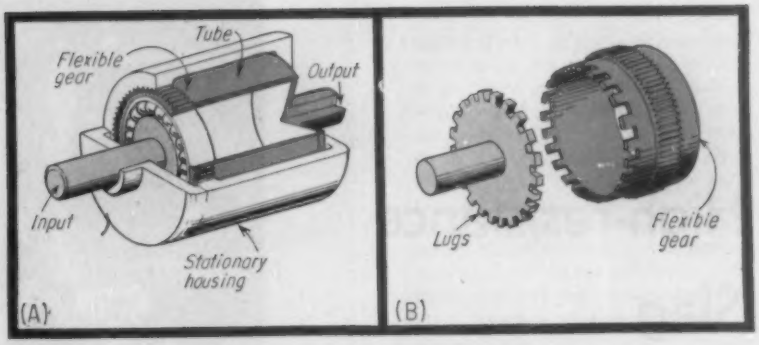
$$e_m = \frac{(1 - f_1 \tan\phi)\ (1 - 0.458\ dnf_2/r)}{R\ (\tan\phi + f_1)\ (f_2 + 0.458\ dn/r)}$$

Output-input relationship

$$T_i = \frac{T_o}{Re_m}$$

Input-torque capacity

$$T_i = T_o \left[\frac{(\tan\phi + f_1)\ (f_2 + 0.458\ dn/r)}{(1 - f_1 \tan\phi)\ (1 - 0.458\ dnf_2/r)} \right]$$



TWO METHODS OF COUPLING flexible gear to shafts: (A) by means of tubing; (B) with lugs.

Coupling to Flexible Member

The flexible gear can be extended in the form of a tube (or cup) made of one or two parts, as shown in (A) above. Flexibility of the tube permits the gear portion to be deflected as if it were a simple ring. Because deflection is small, the tube length need not be large. In addition, the inside space can be utilized to contain a motor, clutch, etc.

Circumferential lugs, (B), give another method of coupling; however, because of the deflection in the flexible gear, only relatively few of the lugs are in actual contact at any one time. This tends to limit the load capacity to the load-bearing capacity of those lugs in actual contact. Also, as the lugs slide radially in and out under a relatively great load, they are likely to wear locally at the point of contact.

Rotary-to-linear Mechanisms

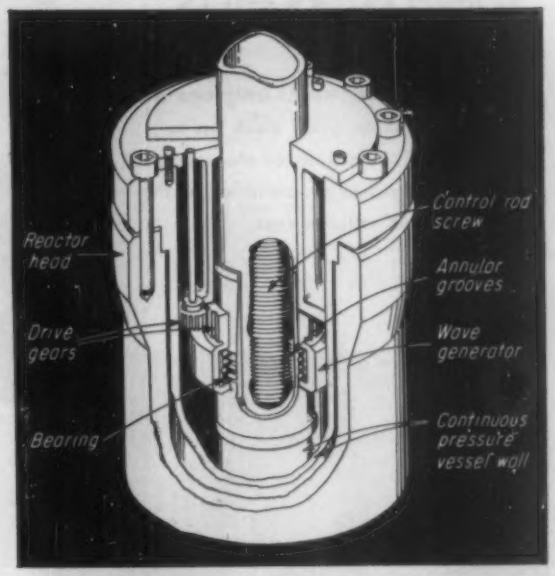
The rotary-linear version of the Harmonic Drive can actuate a rod positively through entirely sealed walls—desirable for applications requiring absolute containment of pressure, vacuum, liquids or contaminants. The drive can provide positive mechanical control without the need for seals and glands.

In the illustration, right, of a nuclear reactor head, the control-rod screw is actuated by rotation of the drive gears without need for a device which penetrates through the inner, continuous-pressure vessel. Inner wall of the flexible tube has annular (zero lead) grooves. The control rod has double-lead threads. The wave generator is elliptical in shape, and when rotated by the drive gears, flexes the inner tube with its annular grooves, causing the minor-axis regions of engagement to progress around the lead screw and produce translation of the control-rod screw—without causing it to rotate.

Characteristics of the drive are:

Maximum operating temperatures, °F	650
Linear speed of control rod, in./min.	20
Length of travel, in.	30
Projected tooth contact area, in.²	2.66
Maximum thread contact stress, psi	1195

The mechanism can be driven by any conventional power source.



ROTARY-TO-LINEAR VERSION moves the control-rod linearly in this nuclear reactor head without need for mechanical contact through the sealed inner tube.

EDITOR'S NOTE: For other recent innovations in planetary gearing see:

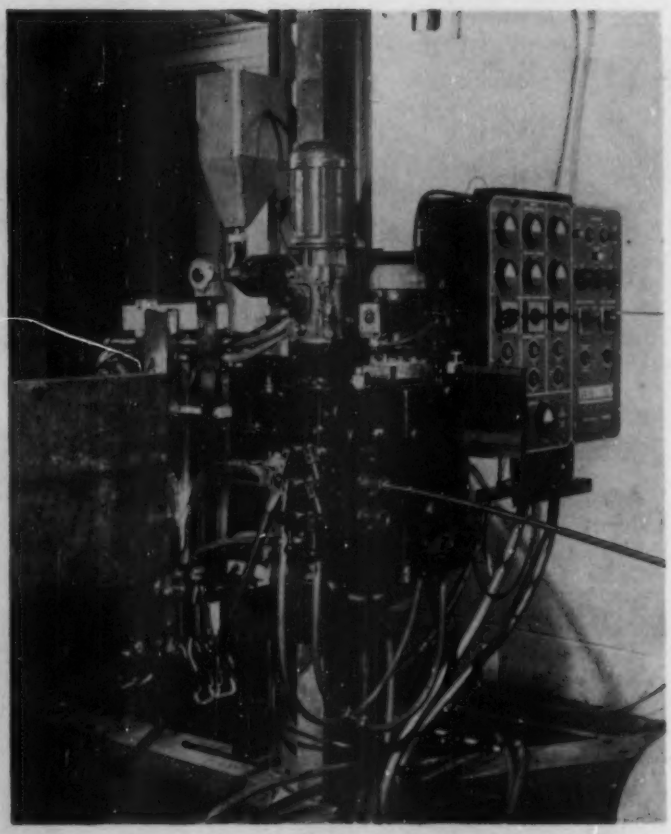
Novel Concept Gives Record Gear Ratios, June 22, '59, p 67—Helical gears are paired with spur gears in an otherwise standard planetary system to provide high speed reductions. A 1:21 drive can be modified to give, say, 1:3600 without adding to weight.

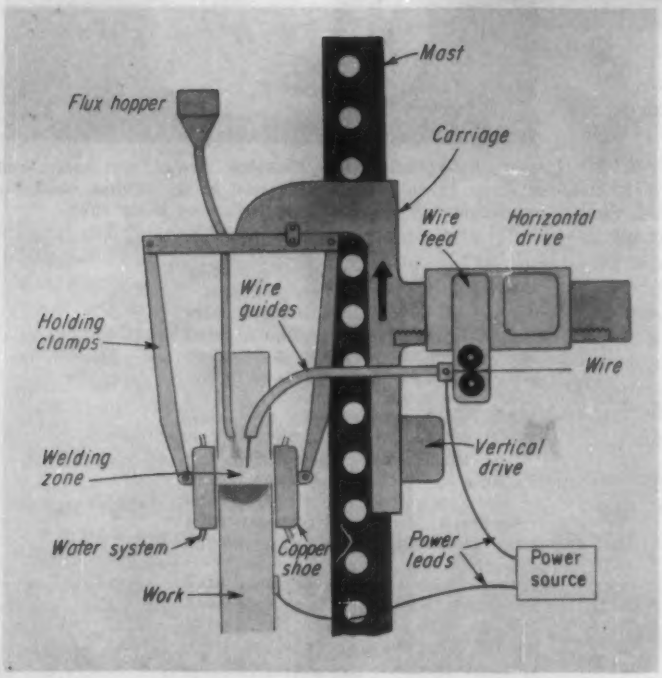
The Planetary Friction Drive, Oct 12 '59, p 79—Preloaded friction rollers in place of gears cut down noise and vibration in high-speed planetary systems. Included is a step-by-step design procedure.

Cam Control Gets More Out of a Planetary Gear, Jan 4'60, p 38. Grooved cam in place of ring gear offers wide variety of output motions to suit application. Includes sample problems.

High-resistance Slag Speeds Welds

This arcless welder needs only one pass to join forgings or plate stock up to 10 in. thick. Elimination of slag-removal operation simplifies preparation of the weld joint and reduces cost.

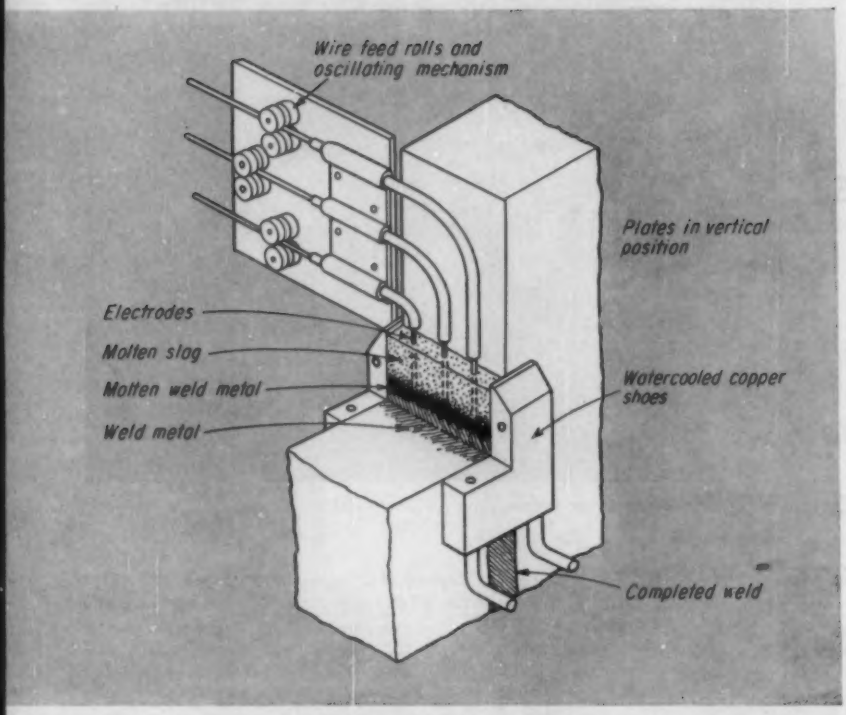




BASIC EQUIPMENT consists of a tripod base with vertical mast on which a boom or carriage is mounted. This carriage, which moves upward as welding takes place, mounts the following equipment: wire guides and a horizontal drive mechanism that moves the guides back and forth; holding-clamps that position two water-cooled copper shoes against the work; also a control panel, flux hopper, and the motor drive used to raise the carriage.

Welding is started in a U-shape starting tab, tack-welded to the bottom of the work. As soon as a sufficiently deep pool of slag is built up, the operator changes the transformer operation from constant current to constant voltage. This is necessary when current flow is transferred from the arc to the molten slag. After the proper electrical conditions for the work have been determined, the operation is fully automatic.

As the pool of weld metal and slag deepens, the vertical drive moves the carriage upward. The watercooled copper shoes move with the carriage and act as a dam to contain the molten slag and weld metal. Welding wire is advanced continuously by the feed mechanism as the wire guides are moved back and forth through the molten pool. This stirring action helps to distribute heat more evenly.



WELD ZONE is the confined area bounded by the workpieces and the watercooled copper shoes. During welding, a slag pool 1 to 1½ in. deep is developed in this zone and produces a path for the electric current between the filler wire and the work. The flow of current through the less resistive slag rather than an arc makes it necessary to use a higher voltage to produce sufficient heat. Approximately 45-55 volts are used to produce the proper coalescence.

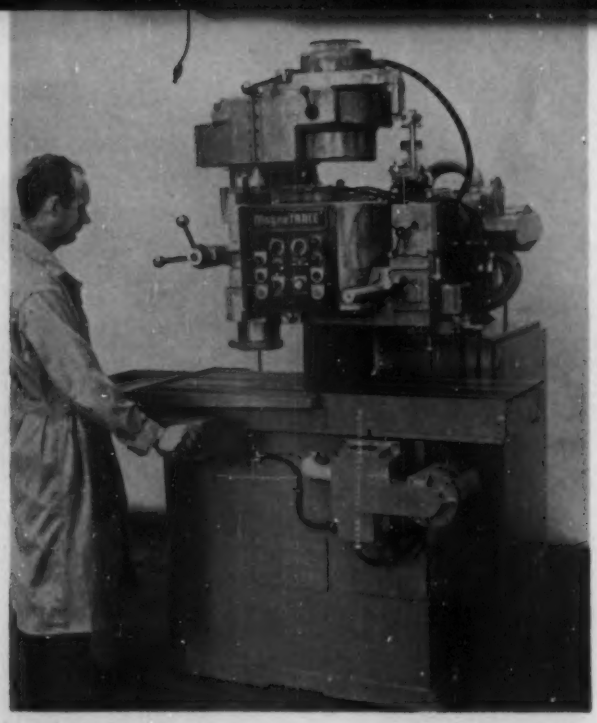
The stirring action produced by moving the welding wire back and forth is intermittent. At the end of each traverse motion the wire continues to be fed but does not move laterally. Because this takes place within a fraction of an inch of the copper shoes, it overcomes their cooling effect. Results: conditions for coalescence and cooling are comparable to those existing in center of the weld.

WATERCOOLED SHOE is made up of three sections. The two end-sections are free to swing on a vertical axis, thus adjusting to any misalignment of the work plates. The center section contains two sensing probes. The upper is a flux-control probe that maintains proper slag height by regulating the flow of flux from the hopper. The lower is a carriage-position probe that controls the vertical drive mechanism. This moves the carriage and shoes upward to keep pace with weld metal deposition. The rising motion takes place only when the wire dwells at one side or the other of the weld before reversing its direction.

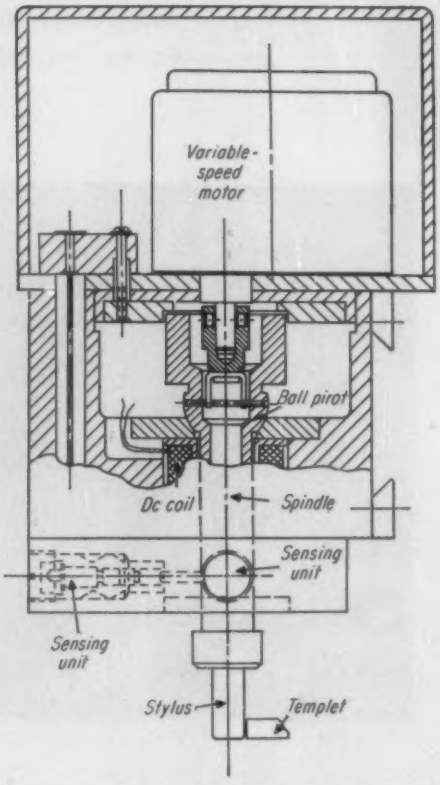
PS . . . Electroslag welding needs no arc—its high temperature is given by molten slag resisting flow of an electric current. The heat melts both the welding wire and adjacent sections of base metal, giving excellent coalescence.

This method requires only a 1-in. weld joint, so uses one-third to one-half less filler material for welding thick plates. Deposition rates of 105 to 135 lb/hr of filler material are achieved by using three electrodes on heavy sections. "Vertomatic" is produced by Arcos Corporation, Philadelphia. (For more on electroslag welding, see PE—Jan 19 '59, P 64.)

Magnetic Stylus Tracks Templet



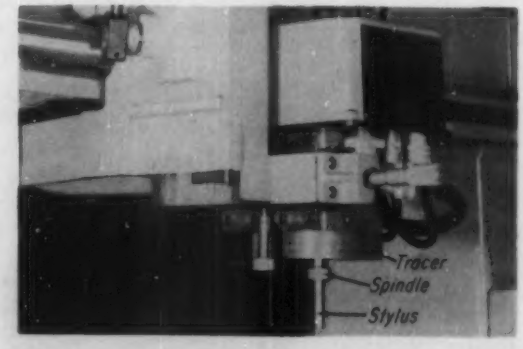
Sensitive tracer system responds to stylus deflection of only 0.0002 in. Tracer follows mild-steel templet at preset feed rate to increase metal removal and reduce cutter wear.



TRACING UNIT carries a spindle mounted in a ball pivot and is free to swing in any direction. A steel stylus, same diameter as the cutter, is mounted on lower end of the spindle. The stylus is magnetized by a dc coil which surrounds but does not touch the spindle. This causes the stylus to cling to the mild-steel templet.

Two sensing elements mounted at 90° to each other detect any movement of the spindle. Output signals from the sensing units are generated by spark gaps mechanically coupled to the spindle. Voltage across these gaps is proportional to width of the gaps, therefore produces an output signal that represents stylus deflection. Electrical contacts in the tracer detect excessive deflection of the stylus in any direction and, by stopping all spindle and feed motions, prevent damage to the tracer.

A variable-speed motor rotates the spindle as the stylus contacts the templet. Rolling action tilts the spindle from the vertical and produces an output signal calling for corrective movements to prevent further tilt. Result is a motion of the tracer stylus along edge of the templet, and of the cutter along the workpiece. Varying the spindle motor speed provides a method of selecting the proper feed rate for the material being machined.



PS . . . Automatic profiler reproduces irregular 2-dimensional shapes from simple templets. "Magnetrace" uses a 5-hp spindle drive and provides 7 speed changes with a range of 375 to 5200 rpm. Produced by New England Machine and Tool Co, Berlin, Conn.

societies and associations offering DESIGN DATA and STANDARDS

WHERE THEY ARE . . .

THEIR OBJECTIVES, MEMBERSHIP AND STANDARDS ACTIVITY

BENEDICT A LEERBURGER JR, *assistant editor*

■ Technical societies and trade associations are important sources of design data and standards in a growing number of fields. How can you make sure you are profiting from all the design guidance they offer? Such sources are scattered; their number is increasing; new standards are constantly being developed. There has been no specific list available. So we're assembling one, as a service to readers.

We started with lists provided by the McGraw-Hill Li-

societies and associations offering design data and standards

brary, then added all the new societies and trade associations we could find. The total offering specific design information and standards came to nearly 200.

Then we sent each a letter asking for basic information about who it is and what help it can offer. Initial response was excellent, but a few holdouts gave us trouble. We sent out a second letter, then a third. Some sources were reached by telephone, but a few resisted us to the end.

Also, some groups, it turned out, offer little design data. These associations, concerned largely with statistics or legislation, and groups concerned only with local or regional interest were generally excluded. The JIC, although it publishes valuable engineering standards, was excluded because it is not a true trade association or society.

So here is what the search boiled down to—fairly complete, and with each listing a potential source of design data. We will welcome suggestions for other groups you feel should be included if a revised list is published later. If some errors reach print, we will be glad to have you correct us.

The problem of classification was solved by listing first the societies with dominant interest in science rather than engineering; then the professional design and engineering organizations, then the technical societies concerned with the engineering function broadly, and finally the groups concerned specifically with testing procedures and standards

The rest of the societies and associations are grouped for their design concern with specific materials and components.

Beneath the name and address of each society or association follows its answer to these questions

1. Purpose of the group
2. Number of members
3. Standards published, other than those listed by American Standards Association

GENERAL SCIENCE

American Assn for Advancement of Science
1515 Massachusetts Ave NW, Washington 5, DC
Promote and further scientific endeavor
58,000 members
No standards

American Institute of Physics
335 E 45th St, New York 17
Promote the advancement and diffusion of knowledge in the field of physics
25,000 members
No standards

American Mathematical Society
190 Hope St, Providence 6, RI
Promote the interests of mathematical scholarships and research
6500 members
No standards

American Nuclear Society
John Crerar Library
86 E Randolph St, Chicago 1
Advancement of science and engineering relating to the atomic nucleus
3200 members
No standards

Electrochemical Society
1860 Broadway, New York 23
Advance the science and technology of electrochemistry, electronics, electrothermics, electrometallurgy and allied subjects
3200 members
No standards

Federation of American Scientists
1805 H Street NW, Washington 6, DC
Concern with the impact of science on national and world affairs
2300 members
No standards

History of Science Society
Widener Library 189, Cambridge 38, Mass
Encourage interest in the history of science
1800 members
No standards

Institute of Aeronautical Sciences
2 E 64th St, New York 17
Disseminate information relating to the science of aeronautics
15,000 members
No standards

PROFESSIONAL DESIGN AND ENGINEERING

American Association of Engineers
8 S Michigan Ave, Chicago 3
Improve the social and economic status of the professional engineer
No standards

American Society of Industrial Designers
15 E 48th St, New York 17
Promote the study and practice of the

profession of industrial design
250 members
No standards

Consulting Engineers Council
326 Reisch Bldg, Springfield, Ill
Promote and safeguard the ethical standards of engineering
24 associations of consulting engineers
Standards

Industrial Designers Institute
18 E 50th St, New York 22
Association of professional men and women concerned with the practice of design for industry
425 Members
No standards

National Society of Professional Engineers
2029 K St NW, Washington 6, DC
Acquaint the public and users of engineering services with the value of engineering as a profession
50,000 members
No standards

Society of Women Engineers
29 W 39th St, New York 18
Encourage the professional advancement of women engineers
800 members
No standards

FUNCTIONAL FIELDS OF ENGINEERING

American Gear Manufacturers Assoc
1 Thomas Circle NW, Washington, DC
Set standards in gear design and application and promote industrial research
Standards

American Institute of Industrial Engineers Inc
145 High St, Columbus 15, Ohio
Advance the art and science of industrial engineering
8000 corporate members
No standards

American Society of Lubrication Engineers
84 E Randolph St, Chicago
Advancement of knowledge and application of the sciences of lubrication
30,000 members
Standards

American Institute of Mining, Metallurgical & Petroleum Engineers, Inc
29 W 39th St, New York 18
Disseminate technical information to those interested in these fields
35,000 members
No standards

American Society of Mechanical Engineers
29 W 39th St, New York 18
Collect and disseminate information valuable to those interested in the field
45,000 members
Standards

American Society for Metals
Metals Park, Novelty, Ohio
Provide information to those working with metals, their production, processing, fabrication, testing, inspection and design
30,000 members
No standards

American Society of Naval Engineers
1012 14th St NW, Washington 8 DC
To publish a technical Naval Engineering Journal
3500 members
No standards

American Society of Safety Engineers
5 N Wabash Ave, Chicago 2
Promote the arts and sciences connected with engineering in its relation to accident prevention—and the conservation of life
7300 members
No standards

Institute of Radio Engineers
1 East 79th St, New York 21
Advancement of electronics, radio and allied branches of engineering
74,000 members
Standards

Instrument Society of America
313 6th Ave, Pittsburgh 22
Advance the arts and sciences related to the theory, design, manufacture and use of instruments and controls
12,000 members
Standards

National Assn of Corrosion Engineers
1061 M & M Bldg, Houston 2, Tex
Promote the prevention of corrosion by encouraging research on fundamental causes of corrosion
6500 members
No standards

Society of American Military Engineers
17th St and Penna Ave NW, Washington 6, DC
Increase the engineer potential of our country for national security
30,000 members
No standards

STANDARDS AND TESTING—GENERAL

American Standards Assn
70 E 45th St, New York 17
Promote development and use of national standards in the US
122 Trade associations
Standards

American Society for Testing Materials
1916 Race St, Philadelphia 3
Promote knowledge of the materials of engineering and standardization of specifications and the methods of testing
16,000 members
Standards

Society for Nondestructive Testing
1109 Ninman Ave, Evanston, Ill
Concerned with all methods of nondestructive testing
4500 members
Standards

Society for Experimental Stress Analysis
PO Box 168 Cambridge 39, Mass
Further knowledge in experimental stress analysis
2000 members
No standards

Standards Engineers Society
1025 Connecticut Ave NW, Washington, DC
Provide a means by which standards engineers and others interested in standardization may discuss standardization
935 members
No standards

TECHNICAL AND INDUSTRIAL ASSOCIATIONS

METALS

The Aluminum Association
420 Lexington Ave, New York 17
Promote general welfare of the aluminum industry and increase usefulness of the industry to the general public
49 member groups
Standards

American Iron and Steel Institute
150 E 42nd St, New York 17
Promote the interests of the iron and steel industry; collect statistics and other information concerning the industry
103 member companies
No standards

Association of Iron and Steel Engineers
1010 Empire Bldg, Pittsburgh 22
Technical and engineering phases of producing iron and steel
8800 members
Standards

Brass and Bronze Ingot Institute
308 W Washington St, Chicago 6
Promote general welfare of the brass and bronze ingot industry
55 member groups
No standards

Copper and Brass Research Association
420 Lexington Ave, New York 17
Stimulate the use of products of the industry; arrange for the collection and distribution of statistics
43 member groups
Standards

Magnesium Association
122 E 42nd St, New York 17
Serve as clearing house for the magnesium industry on developments in products and processes utilizing magnesium
75 member groups
No standards

Tin Research Institute
492 W 6th Ave, Columbus 1, Ohio
Develop the consumption of tin
Member of International Tin Research Council, London

Tungsten Institute
500 5th Ave, New York 36
Advise membership about current domestic activities
4 member groups
No standards

NONMETALS AND PLASTICS

Adhesives Manufacturers Assn of America
441 Lexington Ave, New York 17
Trade association representing industrial packaging, adhesive manufacturers
No standards

Asbestos Textile Institute
c/o Philadelphia Textile Institute
Schoolhouse Lane, Philadelphia 44
Promote ethical business standards in the industry
16 member groups
No standards

Friction Materials Standards Institute
370 Lexington Ave, New York 17
Collect and disseminate specifications and drilling information for automotive brake linings and clutch facings
30 member groups
Standards

Rubber & Plastic Adhesive & Sealant Mfg Council
159 N Dearborn St, Chicago 1
Promote, encourage and advance the use of products of the industry
23 member groups
None as yet

Society of Plastics Engineers
65 Propect St, Stamford, Conn
Promote, develop and disseminate scientific and engineering knowledge relating to plastics materials, products and equipment
8000 members
No standards

Society of Plastics Industry
250 Park Ave, New York 17
Provide assistance to members in their daily problems, drawing upon the experience and ability of the foremost men in the plastic industry
1100 member groups
Standards

FABRICATION PROCESSES

Alloy Casting Institute
286 Old Country Rd, Mineola, LI, NY
Further the development, use and quality of high alloy castings
26 member groups
Standards

Aluminum Extruders Council
1015 Chestnut St, Philadelphia
Collect and distribute industry information
58 member groups
No standards

American Die Casting Institute
366 Madison Ave, New York 17
Trade association of the custom (jobshop) die casting industry
125 member groups
Standards

American Foundrymen's Society
Golf and Wolf Roads, Des Plaines, Ill
Develop and disseminate information concerning the design, production, technology and quality of all cast metals
13,000 members
No standards

American Powder Metallurgy Institute
60 E 42nd St, New York 17
Division of the Metal Powder Industries Foundation
32 member groups
Standards

American Vacuum Society
Box 1282, Boston 9
Promote communication among people interested in vacuum science and engineering
700 members
Standards

American Welding Society
33 W 39th St, New York 18
Advance the art and science of welding
13,000 members
Standards

Drop Forging Association
1121 Illuminating Bldg, 55 Public Square Cleveland 13
Service to producers of forged components made in closed impression dies
80 member groups
Standards

Gray Iron Founders Society
210 Natl City Bldg, Cleveland 14
National trade association representing producers of cast iron in the US, Canada and Mexico
400 member companies
No standards

Investment Casting Institute
27 E Monroe, Chicago 3
Standardize nomenclature, specifications and testing procedure within the industry, and study and publicize the attributes of investment casting
50 member groups
Standards

Malleable Founders Society
1800 Union Commerce Bldg, Cleveland 14
Promote, aid and standardize the association product
49 member groups
No standards

Metal Powder Industries Federation
60 E 42nd St, New York 17
Promote the common interests in powder metallurgy
5 member groups
Standards

National Association of Metal Finishers
60 Bently Road, Cedar Grove, NJ
Dedicated to the welfare of management executives, primarily job-shop owners and operators in the metal-finishing field
500 member groups
Standards

National Foundry Association
52 W Jackson Blvd, Chicago 4
Clearinghouse of foundry industrial relations information and data
265 foundries
No standards

Non-ferrous Founders' Society
1604 Chicago Ave, Evanston, Ill
National trade and management organization of non-ferrous casting producers
304 member groups
No standards

Powder Metallurgy Parts Mfrs Association
Suite 759, 1 Gateway Ctr, Pittsburgh 22
To upgrade the industry by solving problems of design, research and manufacturing
21 member groups
No standards, but has a "Buyer's Guide."

Resistance Welders Mfrs Association
1900 Arch St, Philadelphia 3
Promote resistance welding and assist the member companies
15 member groups
Standards

Society of Die Casting Engineers
19370 James Couzens Hwy, Detroit 35
Through research and education to advance the arts and sciences relative to die-casting
1000 members
Standards

Steel Founders Society of America
606 Terminal Tower, Cleveland 13
Promote the general welfare of users and producers of steel castings
140 member groups
Standards

TOOLING AND PRODUCTION

American Society for Tool and Manufacturing Engineers
10700 Puritan Ave, Detroit 38
Enable members to exchange information on the latest production methods and equipment
40,000 members
Standards

National Assn of Engineering Companies
1800 Buhl Bldg, Detroit 26
Trade association to elevate and maintain the highest standards and principles in the performance of design engineering
40 member groups in Detroit area
No standards

National Machine Tool Builders' Assn
2071 E 102nd St, Cleveland 6
Furnish the manufacturers of special tools and dies with management information and other services that will benefit them
180 member groups
Standards

National Screw Machine Products Assn
2860 E 130 St, Cleveland 20
Represent the interests of manufacturers and users of screw machine products
270 member groups
Standards

National Tool & Die Manufacturers Assn
907 Public Square Bldb, Cleveland 13
Further the interests of contract tool and die shop
1100 members
No standards

Rolling Mill Machinery & Equipment Assn
1026 Farmers Bank Bldg, Pittsburgh 22
Promote the general welfare of its members, its customers and the public
12 member groups
No standards

ELECTRICAL AND ELECTRONIC

American Institute of Electrical Engineers
33 West 39th St, New York 18
Professional society to advance the art of electrical engineering
54,000 members
Standards

Assn of Electronic Parts & Equipment Mfrs
11 S LaSalle St, Chicago 3
Further better understanding and business practices between the manufacturers of electronic parts, equipment and related items, and the distributor
140 member groups
No standards

Electronic Industries Association
1721 DeSales St NW, Washington 6, DC
Trade association representing major manufacturing segments of the electronic industry
350 member groups
Standards

National Electrical Manufacturers Association
155 E 44th St, New York 17
Trade association of manufacturers of electrical apparatus and supplies
540 member companies
Standards

RLM Standards Institute
326 W Madison, Chicago 6
Establishment of high standards for design and construction of industrial lighting units
Standards

HEATING AND AIR CONDITIONING

Air Conditioning and Refrigeration Institute
1346 Connecticut Ave NW, Washington, DC
Serve the public by promoting a recognition of the benefits of air conditioning and refrigeration
150 member groups
Standards

Air Moving and Conditioning Association
2159 Guardian Bldg, Detroit 26
Trade associations solving problems of mutual interest to members
70 member groups
Standards

American Society, Heating, Air Conditioning Engineers
62 Worth St, New York 13
Advance the arts and sciences of heating, refrigeration, air conditioning and ventilation
19,000 members
Standards

Association for Applied Solar Energy
3424 N Central Ave, Phoenix, Ariz
Gather, compile and disseminate information relating to solar energy
1300 members
No standards

Combustion Institute
Union Trust Bldg, Pittsburgh 19
Promote the science and application of combustion
1100 members
No standards

Gas Appliance Manufacturing Association
60 E 42nd St, New York 17
Advance the use of gas as a fuel through the use of modern gas appliances and equipment
600 member groups
Standards

Heat Exchange Institute
122 E 42nd St, New York 17
Promote the interests of manufacturers of heat exchange and steam jet vacuum apparatus
15 member groups
Standards

Industrial Heating Equipment Association
1145 19th Street NW, Washington 6
The spokesmen for the industrial heating equipment industry
56 member groups
No standards

Refrigeration Research Foundation
12 N Meade Ave, Colorado Springs, Col
Stimulate scientific investigation in the field of commodity refrigeration
1023 members
No standards

Steam Heating Equipment Manufacturers Assn
3788 N Holton St, Milwaukee 12
Division of the Fluid Controls Institute

AUTOMOTIVE AND FARM EQUIPMENT

American Soc of Agricultural Engineers
420 Main St, St Joseph, Mich
Promote the science and art of engineering in agriculture
5500 members
Standards

Automobile Manufacturers Association
320 New Center Bldg, Detroit 2
Promote interests of members and disseminate information to the industry
No standards

Farm Equipment Institute
608 S Dearborn St, Chicago 5
The communication and service agency for the farm equipment industry
350 member groups
No standards

Farm Equipment Manufacturers Association
34 N Brentwood Dr, St Louis 1
Promote the business welfare of the independent farm equipment manufacturer
185 member groups
No standards

Internal Combusion Engine Institute
201 N Wells St, Chicago 6
Promote interests of the engine manufacturer; collect and disseminate data
14 member groups
No standards

Outboard Boating Club of America
307 N Michigan Ave, Chicago 1
Promote interest and serve the field of outboard motor engineering, research and education
Standards

Society of Automotive Engineers
485 Lexington Ave, New York 17
An organization wherein engineers meet to exchange information on new developments in automotive transportation
24,000 members
Standards

AVIATION AND MISSILES

Aerospace Institute of America
610 Shoreham Bldg, Washington DC
Perform liaison between Government and industry on noncompetitive matters
Standards

American Rocket Society
500 Fifth Ave, New York City
Promote an interest in the field of rocketry
12,000 members
No standards

Assn of Missile and Rocket Industries
1226 National Press Bldg, Washington 4
Serve companies interested in the missile and space field
No standards

Aviation Distributors and Mfrs Assn
1900 Arch St, Philadelphia 3
Promote friendly business relations and mutual confidences among its members and with others in the industry
42 distributors, 64 manufacturers
No standards

National Aeronautic Association
1025 Connecticut Ave, Washington 6, DC
Use aeronautics and astronautics to advance the best interests of mankind
30,000 members
No standards

United States Pocket Society
Box 271, Pittman, Nev
Disseminate rocket information
1500 members
No standards

ACOUSTICAL

Acoustical Society of America
335 E 45th St, New York 17
Increase and diffuse the knowledge of acoustics and its practical applications
2500 members
No standards

Audio Engineering Society
PO Box 12, Old Chelsea Station
New York 11
Increase educational and scientific knowledge in audio engineering
2340 members
Standards

Hearing Aid Industry Conference
21 N Third St, Minneapolis 1
Bring together the manufacturers of hearing aids and components with a view to improving the status of the industry
12 member groups
No standards

National Noise Abatement Council
51 East 42nd St, New York 17
Promote a national consciousness of the need for noise abatement and control
125 member groups
No standards

MATERIALS HANDLING

American Material Handling Society
3737 Upton St, Toledo 13, Ohio
Advance the theory and practice of efficient material handling
5000 members
Standards

Materials Handling Institute
Suite 759, One Gateway Center
Pittsburgh 22
Promote and advance industrial material handling throughout the industry
8 member groups
No standards

OTHER INDUSTRY ASSOCIATIONS

Association for Computing Machinery
2 E 63rd St, New York 21
Advance the science, design, development construction and application of modern machinery and computing techniques for performing operations in mathematics, logic, statistics, automatic control and kindred fields
5000 members
No standards

National Gadget Manufacturers Association
11032 Magnolia Blvd, N Hollywood, Calif
Establish and implement standards of operations and activities among manufacturers of new, patented products
7000 members
No standards

Scientific Apparatus Makers Assn
20 North Wacker Dr, Chicago 6
Provide a forum for manufacturers and distributors of scientific instruments
225 member groups
Standards

COMPONENTS

batteries

Association of American Battery Mfrs
19 N Harrison St, East Orange, NJ
Represent the interest of American battery manufacturers
200 member groups
Standards

bearings

Anti-Friction Bearing Manufacturing Assn
60 E 42nd St, New York 17
Protect, promote and advance the interest of manufacturers and distributors of anti-friction bearings and steel balls
41 member groups
Standards

casters

Caster and Floor Truck Mfrs Assn
27 E Monroe St, Chicago 3
Association of manufacturers of industrial casters, industrial wheels, and industrial hand and floor trucks
50 member groups
Standards

chain

National Assn of Chain Manufacturers
111 W Washington St, Chicago 2
Trade association comprised of manufacturers of iron and steel chain
15 member groups
Standards in process of being developed

explosives

Institute of Makers of Explosives
250 E 43rd St, New York 17
Promote the general welfare of the explosives manufacturing industry
11 member groups
No standards

fasteners

Industrial Fasteners Institute
1517 Terminal Tower, Cleveland 13
Trade association made up of manufacturers of beaded and threaded products
61 member groups
Standards

Tubular and Split Rivet Council
53 Park Place, New York 7
Develop and improve engineering standards of the tubular and split rivet industry
10 member groups
Standards

hydraulic

Fluid Controls Institute
320 Broadway, New York 7
Further the progress, development and common interests of manufacturer and user of fluid control equipment
75 member groups
Standards

National Fluid Power Assn
5595 N Hollywood Ave, Milwaukee 17
Engage in any activities which may further the application of fluid power to the machines of industry
70 member groups
No standards

relays

National Assn of Relay Manufacturers
c/o Struthers-Dunn Inc, Pitman, NJ
Promote and further the interests of manufacturers of electromagnetic and thermal switching devices
35 member groups
Standards

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* 5 . . . Etiquette for speakers

Your Manners Are Showing . . . All of your nervous habits will show up glaringly when you are on the dais or rostrum. You must school yourself to avoid them. They include scratching your head or other areas less genteel, clearing your throat noisily and frequently, jingling keys or coins in your pocket, twining your fingers, adjusting your tie, and slumping with one foot on the other. By far the worst habit is to open your mouth before you know what you're going to say, necessitating that "uh" or "ah" that signals the audience's in-built accounting system to keep score.

Unless the meeting is very small—like a round table—or you are a member of a panel, STAND UP. Your knees will wobble, but forget them—your voice and breathing will be better. Stand squarely on both feet, and stay that way—don't slouch or roam. If there is a podium, stand to one side or the other of it, so the audience can see you, unless the hall is so large you are forced to use a microphone. Then avoid leaning on the podium or slouching against it. Don't worry about your hands; when you're not using them, let them hang. And know what you're going to say well enough so you don't have to bury your head in your notes. If you can't keep your head and body erect, neither will the audience—and they'll start to snore eventually. Move your body forward for emphasis, sideward to indicate a transition or change of thought.

Microphoning . . . Most microphones work best if your lips are 6 in. to a foot away. If mikes are closer than that, they pick up the sound of your breathing and are so directional that a slight head movement will alter voice volume markedly. Unless you're skilled, try to work without the amplifier, even if it is an engineering triumph, because it will squeal, crackle or hum just when you're making your key point—or you'll become so engrossed in your subject that you'll stray from the mike.

One added point about microphones—they permit a lowered voice, and force you to stay close—so your gestures and intonations will be constricted as they should not be when your voice is filling a room. The chest microphone helps, but adds the problem of the trailing cord, and provides something else to fuss with.

Visual Aids . . . Your audience will get sick of "This is a drawing of . . ." (Of course it is! Tell 'em instead what they should be seeing in it.) Proper handling of visual aids takes showman blood, and routines learned through practice. They're not last-minute additions.

Audibility . . . Visualize yourself as talking to a friend on the other side of a 7-ft wall, so get your head up and your voice "up and over." Have a friend or accomplice at the rear of the audience to signal if he can't hear you—or watch the people in the back row. If they're straining to hear, raise your voice. If you are working with a movie or slides, remember to raise your voice (unless you're wearing a throat mike) if you must talk when you turn to the screen. Don't turn away from the audience if you can avoid it, and it is better not to speak when you do. Check to see that your podium light isn't shining into the eyes of the audience or dimming part of the projected image, that you or your shadow isn't obscuring it. Arrange with the projectionist in advance for a signal for a slide change other than "Next slide, please."

Just Plain Manners . . . If you are dressed and introduced formally, acknowledge your introduction in the same way, citing the dignitaries present by protocol. Usually, it is enough to say, "Mr Chairman, ladies and gentlemen . . ." Watch your manners at the speaker's table; don't talk, smirk or play with the silverware while others are speaking. For your own internal comfort, don't eat or drink heavily before you talk; you can enjoy both more after you've finished. Avoid the banal interchanges of cute private pleasantries with the chairman, the very-personal anecdote, and the corny, "I am reminded of the story of . . ." In fact, don't inject stories unless your enemies have complimented you frequently on your story-telling ability. Don't say the previous speaker has stolen your stories or speech—even if he has. Avoid swear words even if the audience is all male. Look up in advance any quotations you plan to use and credit them to their originators. (Better look up pronunciation of their names too!) Lastly, never act the "visiting fireman" or lecturer even if you are from the Big City, or old and expert.

Dress . . . Only at dinner meetings are you likely to need formal attire, and even that is unusual. But check to be sure. Otherwise, it's best to wear a dark, relatively unpatterned suit, pressed of course, and a white shirt. Avoid extremes: sport or colored shirts, sport costumes, loafers, gaudy socks and neckties, flashy jewelry—unless you're on TV. If you don't look dignified, your audience may tend to assume you are superficial. In most cases, you'd better check colors with your wife.

Next week . . . chairing the committee or the panel.

A reprint will be available including all seven lessons in this series. To get your copy, circle P42 on Reader Service Card.

7 steps to better oral reporting

E J TANGERMAN, *editor*

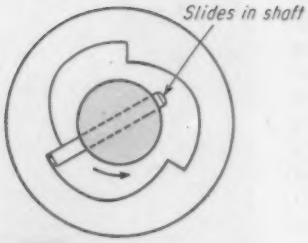
step 1: From ideas to outline
step 2: How to organize a talk
step 3: Now you need notes
step 4: Hints on delivery
* step 5: Platform manners
step 6: Chairing committee or panel
step 7: Chairing a meeting

7 Low-cost Designs for . . .

OVERRUNNING CLUTCHES

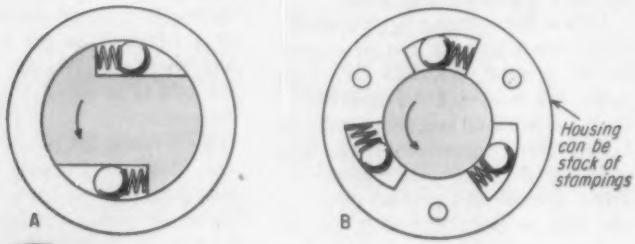
All are simple devices that can be constructed inexpensively in the laboratory workshop.

JAMES F MACHEN, *asst. professor, mechanical engineering, University of Toledo, Ohio*



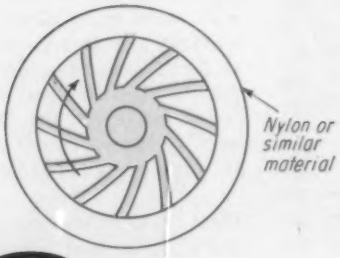
1

Lawnmower type



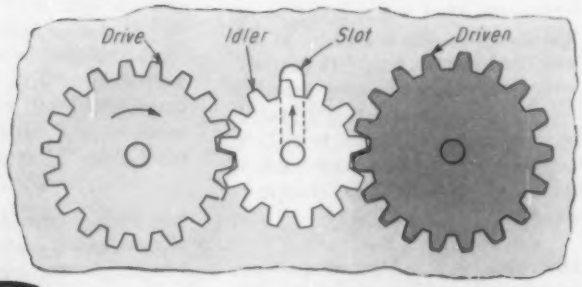
2

Wedging balls or rollers: internal (A); external (B)



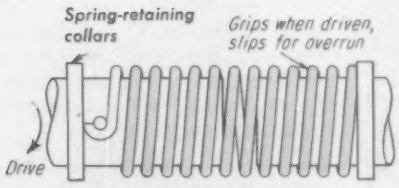
3

Molded sprags (for light duty)



4

Disengaging idler rises in slot when drive direction is reversed

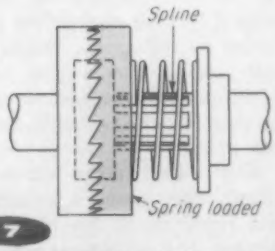


5

Slip-spring coupling

6

Internal ratchet and spring-loaded pawls

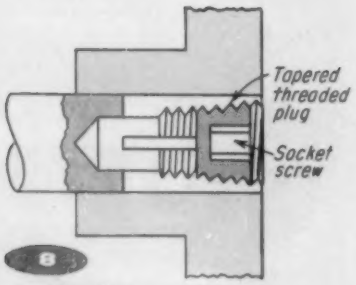


7

One-way dog clutch

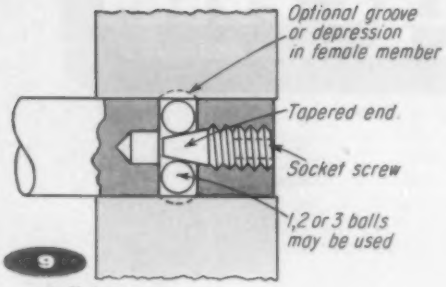
and 5 More, for . . . ADJUSTMENT LOCKS

(FOR ANGULAR AND AXIAL ADJUSTMENT)



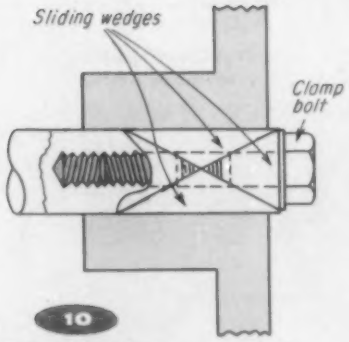
8

Plug jam
(with four axial slots)



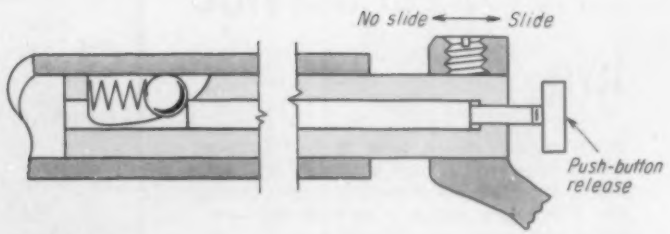
9

Ball jam



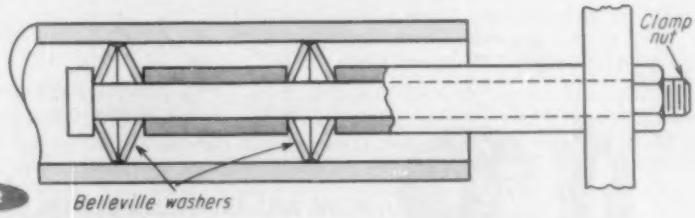
10

Clamped wedges
(for axial adjustment only).



11

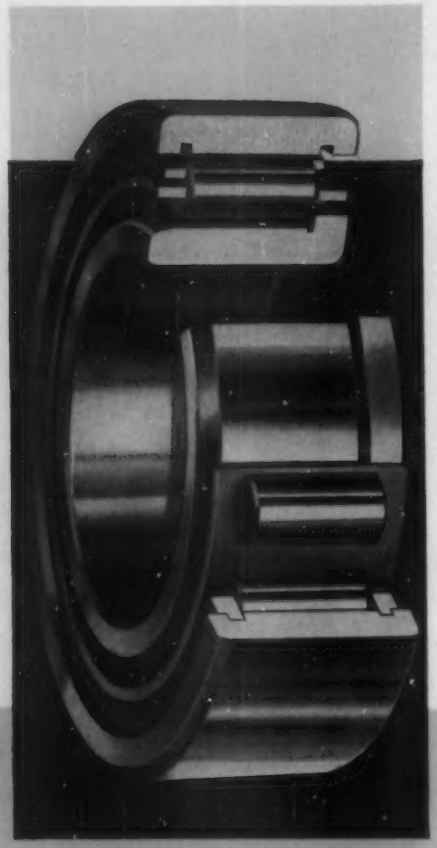
One-way slide-lock



12

Belleville-washer clamp

Aetna
ROLLER BEARINGS

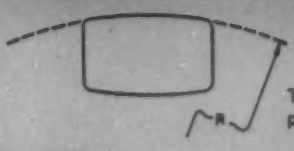


True Crowned for 15% longer service life

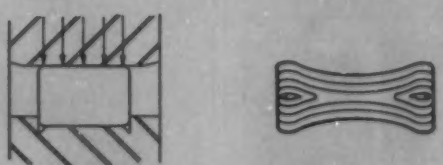
Because each Aetna roller is *True Crowned* with a large radius, high stress points in the rollers are relieved—giving 15% longer bearing life. The crown radius is scientifically determined and varies with the roller size.

Aetna offers a wide range of self-contained *True Crowned* pure radial roller bearings in both custom and standard designs—also many special designs of both pure radial and pure thrust bearings for unusual applications.

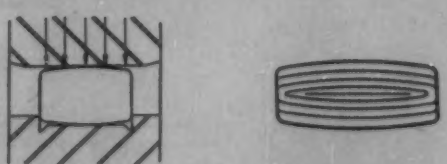
For complete information on *True Crowned* Aetna Roller Bearings, call your Aetna representative listed in your classified telephone directory, or write for General Catalog and Engineering Manual.



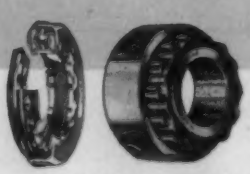
True Crowning as produced by Aetna.



Straight roller showing stress pattern at roller to race contact.



True Crowned roller showing stress pattern at roller to race contact.

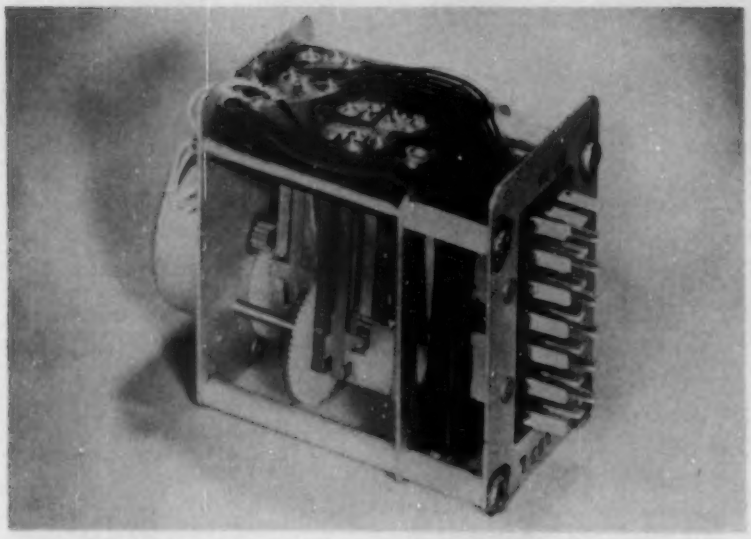


AETNA BALL AND ROLLER BEARING COMPANY
DIVISION OF PARKERSBURG-AETNA CORPORATION

4600 SCHUBERT AVE.
CHICAGO 39, ILL.

ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

SIGNIFICANT COMPONENTS MATERIALS, PROCESSES



Repeat cycle timers . . .

are guaranteed to operate continuously for at least 1 yr. Low-cost units feature spring switches in plastic contact blocks; molded-nylon cams, cam followers and gear assemblies; printed-circuit cables and Jones-type terminal plugs. Approximately 4 x 3 x 2 in., these timers are equipped with clear-plastic dust cover and are available on production basis with voltage, cycling time and programming adapted to particular applications. A W Haydon Co, 232 N Elm St, Waterbury, Conn.

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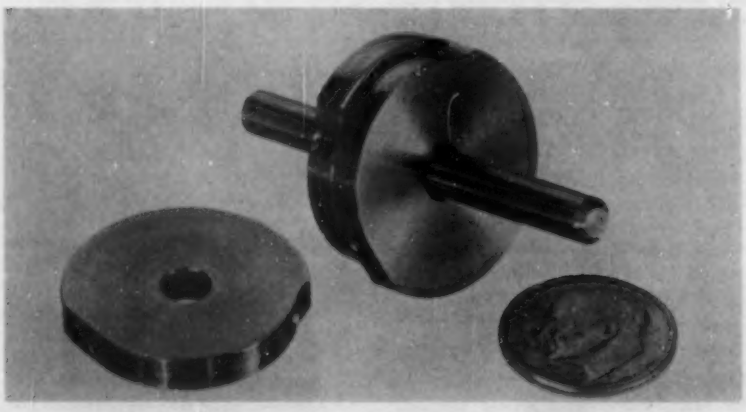


Instrument cams . . .

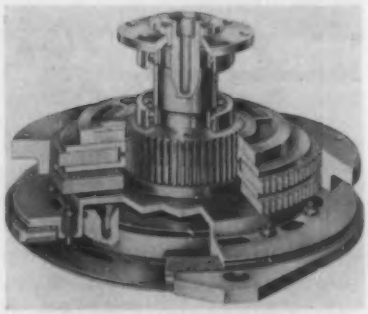
require less shaft space, yet provide two different rise rates each. Two identical, stainless cams make up $\frac{1}{16}$-in.-thick assembly, which has no mounting bushing—cams are mounted directly and independently on shaft. Each cam has one sharp and one gradual rise and is adjustable from 180 to 360° high and 0 to 140° low. Max radius of $\frac{1}{2}$ in. and min radius of $\frac{7}{16}$ in. permit $\frac{1}{16}$-in. differential motion. Adjustable cam assembly is available with bores of 0.187 or 0.250 in. Dual cam assembly is furnished with Bristol or Allen No 4 flat-tip set screws. Priced at $6. Gap Instrument Corp, 116 E Merrick Rd, Freeport, NY.

Circle 301 on Reader Service Card

Elimination of shock and vibration effects . . .

is possible with shaft lock that still permits immediate repositioning of any control shaft with min drag. Input torque is adjustable in either direction, from 2 to 12 in.-oz. But output is positively locked at 30 in.-oz, requiring torque in excess of output in order to rotate shaft. Said to offer chatter-free movement, full adjustability for control of backlash and lost motion, and fail-safe operation with built-in overload protection. Shaft size is $\frac{1}{4}$-in.; rated for 300 rpm, max transfer torque of 100 in.-oz and operating temperature range of —65 to 300 F. Has O-ring seal. Life expectancy is reported to be 1 million cycles. Materials comply with military specifications. Now available in pilot quantities for customer evaluation. $25 per unit. Co-Engineering Co, Boonton Ave, Boonton, NJ.

Circle 302 on Reader Service Card



Combination brake and air-friction clutch . . .

controls single or multiple cycling within wide speed range. Pressure plate, which acts as both clutching and braking member, is moved in one direction by air pressure to engage clutch disks and by spring pressure in opposite direction to apply brake as air exhausts. Absolute min travel is said to achieve fast action in both directions. Automatically synchronized air-operated unit is adaptable for mounting on crank, cam or driveshaft for flywheel or gear application. Can be used with flywheel, gear or drive-spider and mounted outboard or between bearings. Available with clutch torque of 1119.6 through 38,943.9 ft-lb; rated for 5.6 through 464.4 hp at 100 rpm, 55 psi air. Minster Machine Co, Minster, Ohio.

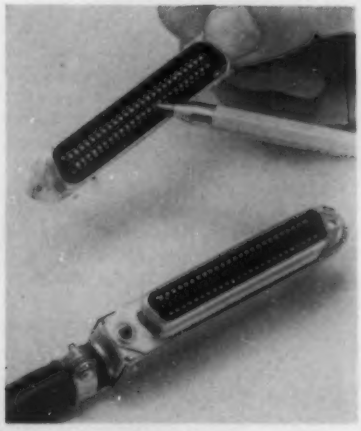
Circle 303 on Reader Service Card

continued on next page

Small 4-digit drum counter

is reversible and has geneva-movement pinions and gears molded of impact-resistant thermoplastic. Drum dia is 0.460 in.; numbers ⅛ in. high. Although counter is furnished with mounting bracket, lugs may be clipped off and two screws used in base for mounting. Over-all dimensions of package would then be ½ x 1⅛ x ⅝ in. long, not including drive shaft. List price is $4.80 with quantity discounts of up to 50%. **Haydon Instrument Co, 165 W Liberty St, Waterbury 20, Conn.**

Circle 304 on Reader Service Card



50-terminal connector . . .

consists of gold-plated, cadmium-bronze contacts held in body molded from diallyl phthalate resin. Electrical connector is particularly applicable to business machines and multiline telephone installations where many low-voltage circuits must be connected and disconnected easily. Plug-in mating members are self-cleaning and both mating contacts are flexible for vibration resistance. **Amphenol-Borg Electronics Corp, 1858 S 54th Ave, Chicago 50.**

Circle 305 on Reader Service Card

Pressure-fitting tension pin . . .

is made in nominal diameters from 1/16 to ½ in. up; lengths as specified. Can be combined, one inside the other. Usable in steel, cast iron, light alloys, plastics or porcelain. Available from stock. **John Gillen Co, Cicero, Ill.**

Circle 306 on Reader Service Card

Air-cooled torque converter . . .

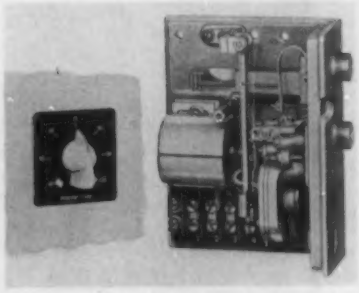
may be used with existing engines from 10 to 50 hp without auxiliary coolant lines, heat exchangers or fans. Has 9-in. wheel and is rated at up to 80 ft-lb torque input. Stall torque ratio is 1.7:1. Unit fits standard SAE No. 4 flywheel housing. Dry weight is 73 lb. Air flow for cooling is provided by fins cast on outside surface of impeller housing. Internal oil circulation is maintained by inherent pressure differentials within converter itself. About $250. Delivery, about 90 days. **Clark Equipment Co, Automotive Div, Jackson, Mich.**

Circle 307 on Reader Service Card

Valve-in-head cylinders . . .

are offered in model for gravity or air return and unit with internal spring to return rod. Both are single-acting cylinders with three-way solenoid valve built into the rear head. Barrels and heads are brass. Rods are ground-and-polished stainless steel. Either model can be furnished in stroke lengths up to 80 in. and in all popular voltages (8, 110 or 220 v). Choice of four mounts or rod clevis. **Allenair Corp, 225 E 2nd St, Mineola, NY.**

Circle 308 on Reader Service Card



Load-limiting relay . . .

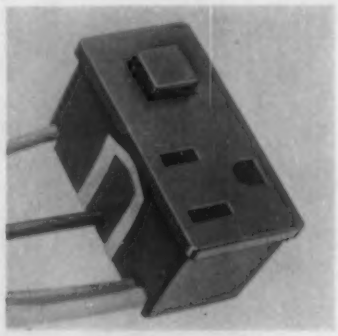
is installed in pneumatic control circuit and responds to motor current. It limits opening of capacity-regulating inlet valves or dampers to maintain predetermined max motor current regardless of demands of other controllers. Remotely located manual adjuster for limiting motor current to any value between 40 and 100% of max can be used to reduce electric demand charges during periods of less-than-max load. Operates at any current between 3 and 7 amp. When used with proper current transformer, can be applied to motors of any size. Delivery, 10 days. **Johnson Service Co, Milwaukee 1.**

Circle 309 on Reader Service Card

Multipurpose oil . . .

for gears, slides, bearings and precision parts is medium-heavy diester oil with over-all temperature range of 40 to 350 F. Said to have low evaporation rate, viscosity index of 174 and resistance to slingoff, dripoff and wipeoff. Oxidational stability is reported to be excellent. Packaged in pint, quart and gallon cans and 5- and 55-gal. drums. **Lehigh Chemical Co, Industrial Lubricants Div, Chestertown, Md.**

Circle 310 on Reader Service Card



Switch and grounded outlet . . .

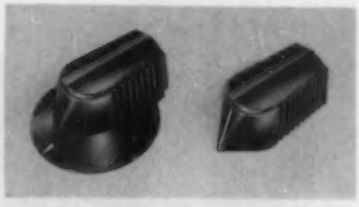
are combined for appliance, utility-cabinet and other applications requiring convenient outlet and switch in small space. Clip permits snap-in panel-mounting for flush installations. Switch is maintained-action, pushbutton unit, rated 3 amp. Outlet is rated 15 amp, 115 v ac. Available in black bakelite or other colors on special order. **Molex Products Co, 9515 Southview Ave, Brookfield, Ill.**

Circle 311 on Reader Service Card

Subminiature toggle switch . . .

carries 5 amp rating at 115 v ac. Said to be capable of handling up to 100% overload. Life-cycle ratings for the switch are over 100,000 operations. Size: ½ x ⅜ x ¼ in. Available from stock in two models. SPDT unit is $1.65 net; DPDT unit is $2.15 net. **Alco Electronic Products Inc, 3 Wolcott Ave, Lawrence, Mass.**

Circle 312 on Reader Service Card



Sloping pointers on bar knobs

are said to eliminate parallax. Available from stock in black or gray, with or without dial skirts, and in mirror or nonreflective matte finish. Colors available on special order. Said to meet military specifications. **Mechanical Component Sales, Commercial Apparatus and Systems Div, Raytheon Co, Waltham 54, Mass.**

Circle 313 on Reader Service Card

Clad molybdenum sheet . . .

is coated by process that joins cladding material and base molybdenum so that two become almost one piece of metal. Standard thickness of cladding (nickel

continued on page 69

Report from James Roberts, Chief Engineer, Galion Iron Works & Manufacturing Co., Galion, Ohio.

"We chose IH power for our pneumatic tire rollers because the wide speed range and favorable torque-speed curve of the International engines make it possible to have low-speed controlled operation for compacting, plus high-speed operation for traveling between jobs," says Mr. Roberts. "Other reasons we chose International were fast parts and service coverage, and operating economy."

GALION'S power choice for new Roll-O-Matic based on 30-year experience with INTERNATIONAL

After specifying IH engines in their road-building equipment for over 30 years, Galion engineers are more convinced than ever of the sale-clinching, profit-building advantages of International power. This long and satisfactory experience shows that 1) International's wide range of power sizes, with features for extreme adaptability in every size, presents a choice that will exactly match design specifications and power requirements. 2) International's world-wide network of parts and service facilities assures prompt attention to on-the-job problems—any time, any place. 3) Galion customers are assured of long-lasting, low-cost power in their road-building equipment. That's why Galion engineers specify IH engines for products like their new 9-wheel, 12-ton, self-propelled, Roll-O-Matic shown above. This new roller, like other Galion products, offers a choice of IH gasoline or diesel power.

When selecting the engine to power your products, check into the complete International engine line—14 carbureted models, 10 diesels, from 16.8 to 385 max. hp. You'll like the one common feature of all 24 engines: fastest payback power for users. Just call or write International Harvester Co., Engine Sales Department, Construction Equipment Division, Melrose Park, Ill.

International UB-220 carbureted engine shown here is interchangeable in the Roll-O-Matic with International UD-236 diesel engine.

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FILTER TIPS

New design information on Purolator Micronic® filters

This new, free bulletin gives the plant engineer complete basic data on Purolator's phenolic resin impregnated, cellulose filter elements. Micronic elements pack maximum filter area into minimum space (up to ten times more than other types); do not channel; are waterproof and warp-proof; have rigidly controlled porosity.

For your copy, write to Dept. MCI-27.

Filtration For Every Known Fluid

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CIRCLE 204 ON READER SERVICE CARD

FILTER TIPS

HYDRAULICS AND LUBRICANTS

The P192 Purolator Micronic Filter Series is a line of small, full-flow industrial filters for general lube work and for hydraulic systems up to 1,000 pounds. Features include:

- The Micronic® Filter element...resin impregnated cellulose, preformed and pleated for greater filtering area. (10 times that of any other.)
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- Handy, easy-to-use replacement element package.
- Mounting brackets on all filters.

Send for details and data, or write us the particulars of your problem. We'll be glad to help. Write Dept. P11-23.

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- COMPLETE INFORMATION ON THE COST-CUTTING SETKO HOPPER FEED METHOD OF INSERTING SET SCREWS.

Lists all standard set screws and socket screw products...plus many special types designed for unusual conditions of vibration; close precision setting; resistance to tampering, etc. Describes many specific ways in which Setko Set and Socket Screw products cut costs and improve product quality.

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- Hopper-Fed Headless Set Screws, with New Automated Feed System
- Self-Tapping Set Screw Standard Hexagon Socket
- Zip-Grip Self-Locking®
- Nu-Cup Set Screws® Self-Locking Offset
- Point-Lok, Flush-Lok, Spred-Lok®
- Isothermal Heat-Treated Set Screws
- Stainless Steel Set Screws, Cap Screws, Button Heads, Flat Heads, Shoulder Screws, Dowel Pins and Pipe Plugs

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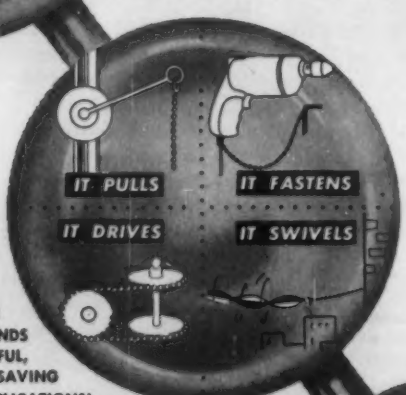

IT HAS THOUSANDS OF USEFUL, COST-SAVING APPLICATIONS!

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THE BEAD CHAIN MANUFACTURING CO.

92 Mountain Grove St., Bridgeport, Conn.

CIRCLE 206 ON READER SERVICE CARD

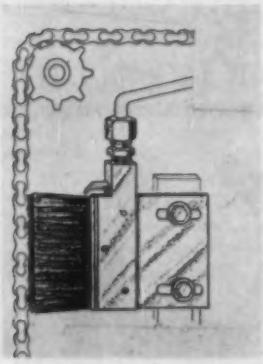
or copper) is 0.0005 to 0.001 in. Sheet is available in thicknesses from 0.010 through 0.080 in. and in widths up to 4 in. Can be supplied with cladding on one or both sides. Now available in commercial quantities. Prices range from about $51 per kg at 40 mil thick to $61 per kg at 10 mil thick. General Electric Co, Nela Park, Cleveland 12.

Circle 314 on Reader Service Card

Aluminum surface coat . . .

is applied cold by mechanical spray equipment to base metal and then subjected to high temperatures in controlled atmosphere. Method achieves diffused alloy bond and produces coating that resists corrosion, oxidation, abrasion and erosion. Total buildup is held within 0.002 and 0.005 in. Recommended for any series-400 stainless steels, all-carbon steels, various alloy steels and austenitic stainless steels. Wall Colmonoy Corp, 19345 John R St, Detroit 3.

Circle 315 on Reader Service Card



Vertical-chain oiler . . .

consists of brush applicator, oil dispenser and copper connecting tubing. Brush, mounted horizontally on aluminum body attached to steel mounting bracket, spreads oil, which is fed to top and seeps through, evenly in thin film on chain. Brush size is determined by chain size and operating conditions. Standard sizes are ⅜, 1, and 1½ in. dia and a ⅜ x 2½ in. rectangular brush. Can be operated with manually or automatically controlled oil dispensers. Oil-Rite Corp, 2382 Waldo Blvd, Manitowoc, Wis.

Circle 316 on Reader Service Card

Proximity switch . . .

can be used as limit, interlock, counter or indicator sensor under such unfavorable environments as those created by oil, grit, extreme vibration, dirt or sludge. Consists of sensor and separate transistor-equipped amplifier with plug-in relay. Sensor detects magnetic material without physical contact and feeds electrical output to remote bistable amplifier, which operates DPDT relay wired to circuit in same manner as conventional limit switch. Two components may be located up to 150 ft apart without use of shielded wire. Sensor, which measures 1.63 x 1.63 x 3.75 in., has stainless sensing face protected by sealed metal enclosure. Amplifier measures 4.5 x 6.94 x 4.25 in. Unit has adjustable sensitivity range of ⅛ to ½ in. Can be energized from 115 v, 60 cps power. Can perform 700 operations or more per min. Package is $98, list. Micro Switch, Freeport, Ill.

Circle 317 on Reader Service Card

Fluid silicone-rubber . . .

sets at room temperature and requires no catalyst premixing. Primarily for use as sealant or adhesive, material adheres to most clean surfaces, including metals, glass, silicone or organic resins and silicone rubber. Material becomes tac-free within 1 hr; completely cured in 24 hr. Resiliency is retained in −70 to 300 F continuous service or to 500 F for shorter periods of time. Said to be highly resistant to oxidation, moisture, weather effects and ozone. Available in 2- and 8-oz collapsible tubes. Dow Corning Corp, Midland, Mich.

Circle 318 on Reader Service Card

Photoelectric control . . .

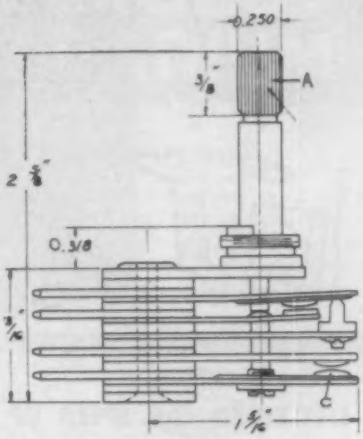
detects objects smaller than 0.05 in. dia (as small as 1/1000 mm with careful focusing). Can operate as close as 1 in. or as far as 80 ft from object. Light source, photocell and transistor-equipped amplifier are combined in single package, 3⅜ x 2 1/16 x 5⅛ in. Single lens serves for exit and return of light beam. System is said to be insensitive to ambient light, shock and vibration and to be easy to install and maintain. Wiring is required to one side only. Priced at $137.50 each. Delivery from stock. Presin Co, 2014 Broadway, Santa Monica, Calif.

Circle 319 on Reader Service Card

½-in. in-line valve . . .

with flow coefficient of 7.5 is rated for 300 psi max at 180 F. Valve is 2¾ in. dia and 3½ in. long, including hexagonal screwed connections. Ported on both sides of operating piston, valve can be assembled for spring-to-open or spring-to-close operation. Springs of different rates are available to suit operating conditions. Can be operated without spring as double-acting piston for hydraulic actuation by any displacement methods. Geo W Dahl Co Inc, Bristol, RI.

Circle 320 on Reader Service Card

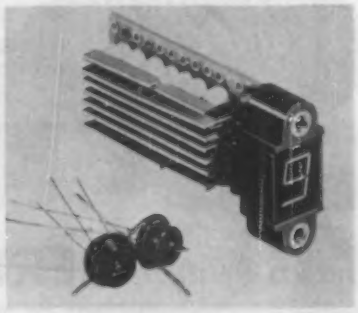


NOTE: OPEN POSITION

Double-pole thermostat . . .

can be used as combination thermostat and manual on-off switch on many appliances that have these two controls separated. When adjustment control is turned to lowest position, device breaks both poles of input lines. When adjustment knob is in temperature control position, unit functions as standard open-blade thermostat. Norwalk Thermostat Co, 52 Woodlawn Ave, Norwalk, Ohio.

Circle 321 on Reader Service Card



Subminiature in-line readout . . .

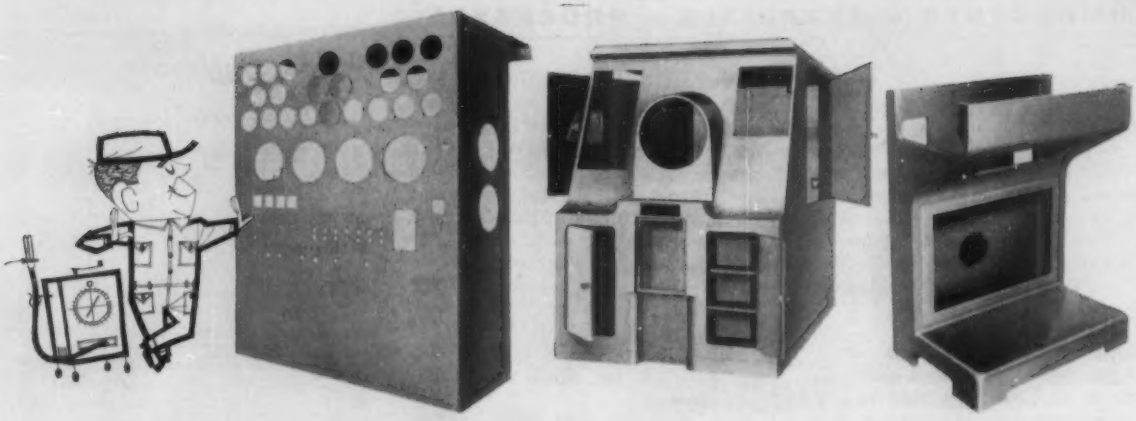
with life expectancy over 60,000 hr at 5.5 v offers in-plane, digit-character size of 1/16 x ½ in. Illuminated by miniature incandescent lamps. Has 11 inputs: common, and 0 through 9. Operates on 4.5 to 6 v, dc or ac. Weighs 1 oz. Electronic Equipment Div, IDEA Inc, 7900 Pendleton Pike, Indianapolis 26.

Circle 322 on Reader Service Card

All-purpose pressure hose . . .

is said to be noncorrosive, fungus-resistant and nonconductive. Made of nylon inner tube reinforced with yarn and abrasion-resistant cover. Said to be one-fifth the weight and to have wall thickness less

continued on page 71



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CIRCLE 70 ON READER SERVICE CARD

CIRCLE 208 ON READER SERVICE CARD

than one-half of rubber hose with equivalent burst strength. Retains flexibility and toughness in temperatures to −65 F and can function constantly up to 200 F, intermittently to 300 F. Two types, with recommended max operating pressures of 1250 and 2000 psi, are available with ID of $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$, $\frac{1}{2}$ and $\frac{1}{2}$ in. **Polymer Corp, Reading, Penna.**

Circle 323 on Reader Service Card

Vane axial blower . . .

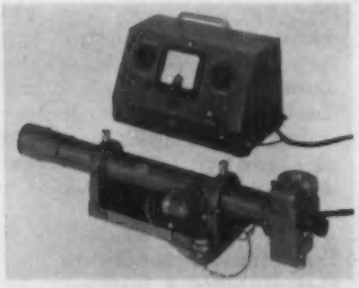
said to exceed environmental tests required by MIL-E-5422D, is powered by motor $2\frac{5}{16}$ in. dia. At 10,500 rpm, blower delivers 200 cfm at $\frac{3}{4}$ in. water gage with a 200-v, 3-phase, 400-cps source. Withstands ambient temperature of 185 F and has life in excess of 5000 hr. Also said to meet MIL-E-5400B. Weighs $3\frac{1}{2}$ lb. Housing measures 4 in. dia by $4\frac{1}{2}$ in. long. **Air-Marine Motors Inc, 369 Bayview Ave, Amityville, NY.**

Circle 324 on Reader Service Card

Valve limits speed . . .

by controlling flow into hydraulic motor when max setting is reached. When inlet pressure reduces to 15 psi, valve automatically resets and permits normal flow, 7.2 gpm. Max allowable flow is 3.5 gpm; limited flow, 0.5 gpm. Pressure drop across valve is 20 psi max for normal flow. Constructed of stainless steel, with bulkhead fitting on outlet port. Handles usual hydraulic fluids. **Fluid Regulators Corp, 313 Gillette St, Painesville, Ohio.**

Circle 325 on Reader Service Card

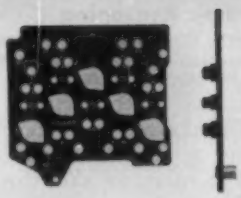


Photoelectric collimator . . .

that reads to 0.1 sec of arc eliminates repeated observation through eyepiece when making exact settings. Can be used wherever visual instrument has been applied for precise testing of angles, circular divisions, straightness, flatness and alignment. Electronic readout, operated from photoelectric cell at eyepiece, provides display on meter of self-contained unit. Meter zero can be set and sensitivity adjusted to fit most operating conditions. **Engis Equipment Co, Div Engineering and Scientific Instrumentation, 431 S Dearborn St, Chicago 5.**

Circle 326 on Reader Service Card

PRODUCT DIGEST from U.S. RADIUM



EDGE-LIGHTED PANELS

Special-purpose panels and dials accurate to MIL spec are available from United States Radium Corporation. Standard edge-lighted and integral edge-lighted products by Lackon® provide optimum legibility and contrast, with high resistance to humidity, surface abrasion. **Request Bulletin 10.30 P2.**

DIALS, PANELS AND NAMEPLATES

Metal dials and panels include a greater variety of finishes, colors and processes than ever before. **Request Bulletin 10.30 P2A.**

New lithographed nameplates and panels featuring special hard, abrasion-resistant finish are available with or without adhesive backing in various thicknesses.

CATHODE-RAY TUBE PHOSPHORS

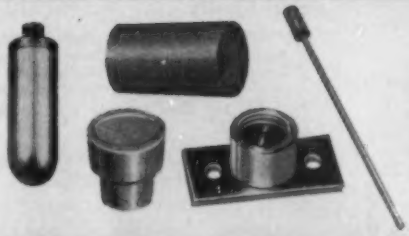
USR offers a variety of phosphors for TV and industrial cathode-ray tube applications. **Request CRT NOTES.**

RADIATION SOURCES FOR ELECTRON TUBE IONIZATION

Specially-fabricated isotope sources—Ni^{63} plated electrodes and radium foil—are now being produced as ionization sources for electron tubes.

ISOLITE LIGHT SOURCES

New 360° light source and high-brightness one-way lamps use luminescent bulbs energized by Kr^{85} gas. Units visible at 500-2000 ft., depending on model, size, color; service life to 10 years. New Isolite markers, signs and placards now available. **Request Bulletin 30.32 P2.**



RADIATION SOURCES

Sealed beta, gamma and neutron sources for research, gauging, radiography and related applications are available with varying intensities and energies. **Request Bulletins 20.20 PB2, 20.30 PG2, 20.40 PN2.**

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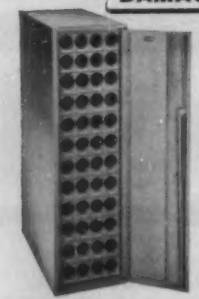

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DESIGN LITERATURE

An Introduction to Economic Reasoning

ROBINSON, MORTON and CALDERWOOD. Brookings Institution, 722 Jackson Pl, Washington 6, DC, 6¼ x 9¼, 335 pp. $3.

Like most other Americans, PRODUCT ENGINEERING readers do not have the time or the inclination to become expert in economics. Yet they know the security of our jobs, our country and our families may well depend on our ability to help influence economic policies proposed daily by our employers, organized management and labor, and the government itself. This book is a good first step towards gaining the necessary understanding of economics. It is a revised edition of a volume first published some years ago as a text for adult discussion groups and as a handy reference for use with the daily newspaper.

The first chapter describes our national economic goals. Succeeding chapters analyze national income, competition, influence of unions, debt and money, prosperity, depressions and their control, economic growth, international trade, and the role of the government.

The authors could have probed much more deeply into future sources of potential trouble for our economy, such as the cult of perpetual growth—by which most of its followers mean constantly increasing consumption. The reader could be guilty of a similar shortcoming if he does not follow up this book with further investigation of this field guided by his own economic and political philosophy. —JK

Theory of Plates and Shells

STEPHEN P TIMOSHENKO, Professor Emeritus of Engineering Mechanics, Stanford Univ, and S WOINOWSKY-KRIEGER, Professor of Engineering Mechanics, Laval Univ. McGraw-Hill Book Co, 330 42nd St, New York 36. 6 x 9, 580 pp. $15.

A thorough revision of one of Professor Timoshenko's advanced volumes. As before, it discusses the deformation of bodies in which one dimension (the thickness of a plate or shell) can be considered as small in comparison with the other dimensions.

All material has been extensively revised in the light of the wealth of literature published in the field of plate and shell theory and design since 1940, when the first edition was published. Account is taken of new methods and new aspects that have gained ground in recent years, and of numerical results now available.

FHP Motor Handbook

Bodine Electric Co, 4500 Euclid Ave, Cleveland 3. 6½ x 9½, 66 pp. $1.

A neatly organized little handbook that summarizes all the practical information needed by motor users. Motor theory is not given—it is left to the many good textbooks already available. Motor types covered are split-phase, shunt- and compound-wound, capacitor and capacitor-start, polyphase, reluctance, hysteresis, shaded-pole, series-wound, electric-governor-controlled series-wound, and servo-type control motors.

The Cathode Ray Tube and Its Applications

G PARR and O H DAVIE. Reinhold Publishing Co, 430 Park Ave, New York 22. 6 x 9, 433 pp. $9.50.

This third edition brings up to date the development of cathode ray tubes and oscillography, with discussions of the power supplies, amplifiers, transducers, and other auxiliary equipment required. Covered are history, construction, performance, theory, time-base, calibration, photographic recording, typical applications (including mechanical, electrical, nuclear), and measurement techniques.

Explosions, Detonations, Flammability & Ignition

S S PENNER and B P MULLINS. Pergamon Press Inc, 122 E 55th St, New York 22. 6 x 10, 287 pp. $10.

This monograph reviews current knowledge of explosions and their prevention, detonation, flammability, and ignition. The authors cover the same material from entirely different, but complementary, viewpoints. One is analytical; the other, semi-empirical and practical. Part I emphasizes the powerful technique in theoretical combustion research introduced by Schvab and Zeldovich. Part II gives

continued on page 73

the results of experimental and theoretical studies of flammability, ignitibility and explosion prevention.

Handbook of Automation, Computation, and Control

EUGENE M GRABBE, SIMON RAMO, DEAN E WOOLDRIGE. John Wiley & Sons Inc, 440 Fourth Ave, New York 16. 5¾ x 9, 1001 pp. $17.50.

This is Vol 2 of a three-part handbook that attempts to summarize all known information on automatic control. Vol 1 is Control Fundamentals: Vol 3 will be Systems and Components.

This one includes computers and data processing, is written by over 40 experts from universities and industry, and covers in profuse detail the following: computer terminology, digital computer programming, the use of digital computers and data processors, design of digital computers, design and application of analog computers, and unusual computer systems.

Electrical Input Transducers

KURT S LION, Associate Professor, Massachusetts Institute of Technology. McGraw-Hill Book Company Inc, 330 W 42nd St, New York 36. 6 x 9½, 324 pp. $9.50.

This book (full title: *Instrumentation in Scientific Research: Electrical Ingot Transducers*) is a general summary of the many devices, techniques and principles important to sensing and indicating temperatures, magnetic fields, force, and other electrical, mechanical, thermal and radiation phenomena. It covers theory, performance and construction of the numerous transducer elements or methods available, including: resistive, inductive, capacitive, and ultrasonic systems; radiation thickness gages; thermal displacement; piezoelectric; ionization; mechanic-optical; electric gas discharges; electrolytic dilution; hot-wire probe; thermal system (humidity); nuclear magnetic resonance; noise thermometer; induction search coils; Hall-effect; magnetoresistive; charged-plate electrode; electron optical; Wilson plate; vacuum photo-electric cells; thermionic detector; geiger counters; spark counters; and numerous others.

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ABSTRACTS FROM THE LITERATURE

Self-extinguishing Plastics

Wall chart lists all self-extinguishing elastomer compounds available at time of publication. It is broken down into three sections: resins and molding compounds; film, sheeting and laminates; plastic foams. Tradenames, tests passed, properties, manufacturers names are given.

"Modern Plastics Chart of Self-extinguishing Plastics Materials." Modern Plastics, Nov '59, 575 Madison Ave, New York 22.

Power Transmission

A collection of data on various types of mechanical power-transmission equipment now available. Belt, chain and gear drives are discussed, as well as various types of coupling systems: clutches, fluid couplings, hydraulic torque converters. All principal types of equipment are illustrated by line drawings, a table compares properties and capabilities. Other tables and curves compare coupling systems, show their respective torque-speed characteristics. Bibliographies of recently developed data are included.

"Mechanical Power Transmission," Cheaney, Paullus, Raridan, Bachmann; Mechanical Engineering, Dec '59, 29 W 39th St, New York 18.

Bearing Materials

Selection of materials for different types of bearings to minimize effects of friction and wear is discussed. Materials considered are separated into three types, according to whether they are to be used for full, partial or dry lubrication. Tables and charts provide

continued on page 75

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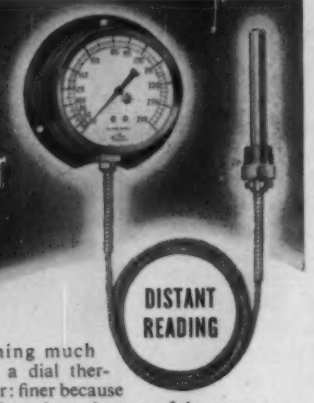

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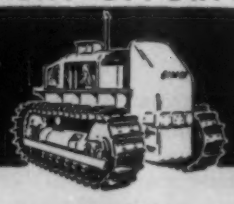

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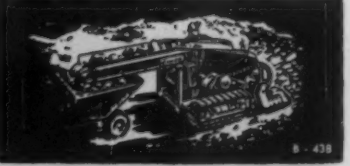

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data on effects of lining thickness; rate of crankpin wear; ratings for resistance to wear, seizure, corrosion; frictional properties; load-speed curves.

"How to Choose Materials for Bearing Materials," P. G. Forrester, Glacier Metal Co Ltd; Engineering Materials and Design, Oct '59, Drury House, Russell St, London W C 2, England.

Color—Paint or Mold-in?

Economics and relative quality of finishes for coloring molded plastics integrally vs painting in a separate process are discussed. Included are basic calculations and tables giving comparative costs for general-purpose polystyrene.

"Painting vs Molding in Color," T. E. Hayden, Bee Chemical Co; SPE Journal, Jan '60, 65 Prospect St, Stamford, Conn.

Plastic Foams

Phenolic, polysterene, vinyl, urethane, polyethylene, epoxy, silicone and cellulose acetate foams are listed, with comments on their advantages, disadvantages, forms in which they are supplied by manufacturers, how they are prepared for use, applications. A table gives their properties.

"Plastic Foams—a Directory," C. R. Davall, Union Carbide Plastics Co; SPE Journal, Nov '59, 65 Prospect St, Stamford, Conn.

Factors in Gear Design

A table of types of gear loads likely to be encountered in 20-odd types of industrial equipment is provided, together with a check list of 12 types of data that should be available before design of gearing begins.

"Presentation of Gear Design Data," R. Gardiner, David Brown Industries Ltd; Engineering Materials and Design, Oct '59, Drury House, Russell St, London W C 2, England.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 76.

CONVEYOR-CHAIN DESIGN – Manual, 36 pp. Outlines and illustrates correct application of chains to conveyor systems, development of attachments to increase their versatility and selection factors. Also includes comparison charts, installation tips. Moline Malleable Iron Co, St Charles, Ill.

Circle 340 on Reader Service Card

FLUID-POWER ACCESSORIES—Catalog 60, 64 pp. Covers descriptions, dimensions and specifications of JIC flared-tube fittings, pipe fittings, hose fittings, valves and miscellaneous hydraulic accessories. L & L Mfg Co, 21590 Hoover Rd, Warren, Mich.

Circle 341 on Reader Service Card

METAL SHAPES—Catalog OS-1059, 48 pp. Illustrates, actual size, over 500 roller-die, cold-formed metal shapes and tubing for which rolls and dies are on hand. Van Huffel Tube Corp, Warren, Ohio.

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INDUSTRIAL HOSE AND ACCESSORIES—Industrial catalog 204, 36 pp. Descriptions and specifications of range of hose types, fittings, adapters, self-sealing couplings, and miscellaneous accessories. Selector chart is included. Aeroquip Corp, Jackson, Mich.

Circle 343 on Reader Service Card

IMPREGNATED FELT TAPE—Folder, 16 pp. Discusses range of typical applications including uses as antivibration material, bedding material, general and special shape gasketing and packaging and crating material. Coast Pro-Seal & Mfg Co, 2235 Beverly Blvd, Los Angeles 57.

Circle 344 on Reader Service Card

POWER-CONTROL SYSTEMS—Bulletin 59-P, 32 pp. Covers applications, engineering information, subsystems and system-component operating characteristics, and recommended standard combinations of rotary electromechanical systems. Electric Specialty Co, 211 South St, Stamford, Conn.

Circle 345 on Reader Service Card

ESTIMATING ALUMINUM CASTING WEIGHTS—Booklet, 16 pp. Outlines procedures employed in computing weights that are basis for firm quotations. Aluminum Association, 420 Lexington Ave, New York 17.

Circle 346 on Reader Service Card

STEPPER MOTORS AND DEVICES—Brochure SP9-1, 12 pp. Product features, application and construction information is given for line of stepper motors and pulsed stepping devices. Contains schematic drawings of application circuitry as well as pulse profiles. A W Haydon Co, 232 N Elm St, Waterbury, Conn.

Circle 347 on Reader Service Card

PROCESS EQUIPMENT – Bulletin G-3C, 12 pp. Discusses applications and performance characteristics of pumps, pneumatic conveyors, fluidizing conveyors, rotary compressors and vacuum pumps, and other equipment for the process industries. Text is supplemented by 31 photos, 6 drawings, 12 schematics and 7 tables of dimensions and capacities. Fuller Co, Catasauqua, Penna.

Circle 348 on Reader Service Card

HARD-FACING SERVICES—Brochure, 6 pp. Specifications and typical applications for various hard-facing processes, such as plasma-jet coatings, metal and ceramic spraying. Cleveland Hard Facing Inc, 3047 Stillson Ave, Cleveland 5.

Circle 349 on Reader Service Card

IMPERVIOUS GRAPHITE EQUIPMENT—Catalog, 32 pp. Contains typical drawing or illustration of each type of equipment, lists standard available models, and provides approximate cost per sq ft of heat-transfer area for exchangers; and other appropriate cost units for other types of equipment. Falls Industries Inc, Aurora Rd, Solon, Ohio.

Circle 350 on Reader Service Card

AIR DIRECTIONAL VALVES—Catalog, 16 pp. Lists 1172 different air directional valves. Includes 9 basic valves and 55 operators with dimensions, capacity, weight and JIC symbols. Westinghouse Air Brake Co, Wilmerding, Penna.

Circle 351 on Reader Service Card

PNP AND NPN TRANSISTORS—Brochure G-200, 16 pp. Describes line of PNP and NPN transistors, and gives specifications, characteristics. Applications chart is included. General Transistor Corp, 91-27 138th Pl, Jamaica 35, NY.

Circle 352 on Reader Service Card

EDDY - CURRENT COUPLING DRIVES—Bulletin GEA-6885, 12 pp. Contains information on eddy-current coupling-operating principle, as well as torque capabilities, regulation and operation of packaged adjustable-speed drives. General Electric Co, Schenectady 5.

Circle 353 on Reader Service Card

PLASTIC FILTER MATERIAL—Manual 3, 10 pp. Describes material capable of removing sub-micron particles from fluids and gases. Discusses methods of

continued on page 76

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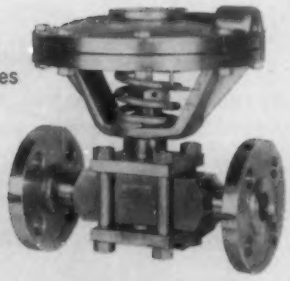

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DESIGN LITERATURE.....continued

isolating, sizing, counting and identifying fine particles and techniques for use in industrial control. Gelman Instrument Co, PO Box 86, Chelsea, Mich.

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UNIT AIR FILTERS—Bulletin 207, 12 pp. Covers construction and application of permanent, washable, unit air filters. Explains filter maintenance methods and equipment necessary. Includes charts, arrestance-resistance curves, dimensions and ratings, shipping weights and dimensional drawings. American Air Filter Co Inc, Dept PD, 215 Central Ave, Louisville 8, Ky.

Circle 355 on Reader Service Card

METER-RELAYS—Catalog, 12 pp. Dimensions, typical circuitry, ordering specifications and prices of expanded-scale meter-relays with high accuracies. Assembly Products Inc, Chesterland, Ohio, and Voltron Products, 1010 Mission St, South Pasadena, Calif.

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STRAIN GAGES AND TRANSDUCERS —Bulletin BBUC959, 6 pp. Basic features of 15 standard models of strain-gage and transducer-input conditioning equipment for conversion of output of variable-resistance transducers from variable resistance to controlled and calibrated milliv signal. Covers applications, installations, limitations and characteristics. B & F Instruments Inc, 3644 N Lawrence St, Philadelphia 40.

Circle 357 on Reader Service Card

LOCATING LEAKS IN VACUUM SYSTEMS—Bulletin GET-2935, 4 pp. Information on how to use halogen-sensitive vacuum-leak detectors to locate leaks down to 1 x 10^{-6}cc per sec. General Electric Co, Schenectady 5.

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LETTERHEAD REQUESTS ONLY

Manufacturers who published following literature asked that requests for copies be made on company letterheads.

CUSTOM-MOLDED PLASTICS – Brochure, 8 pp. Presents value-analysis approach to design and purchase of plastic parts and components. Case histories of parts are cited. Chicago Molded Products Corp, 1020 N Kolmar Ave, Chicago 51.

HONEYCOMB SANDWICH DESIGN —Brochure, 45 pp. Offers summary of sandwich-design methods, with formulas and worked-out examples for stress computations on typical sandwich structures. Includes results of test and research work in graphs and charts. Also contains bibliography. Hexcel Products Inc, 2332 Fourth St, Berkeley, Calif.

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These busy enemies cause metals to corrode, lenses to become frosted, electrical insulation to fail. Jan 18 Circle P 29

Fluids for Power and Control

Practical guide to choosing and using the right hydraulic fluid. Jan 18 Circle P 28

Critical Frequency of Stepped Shafts

Equation provides time-saving way to find natural frequency. Jan 11 Circle P 27

Cam Control Aids Planetary Gear

How a grooved cam can assist in obtaining a wide variety of output motion. Jan 4 Circle P 26

Reserve Strength in Metal Parts

More help on how far you dare exceed the yield strength. Dec 21 Circle P 25

Multi-variable Experiments Simplified

A tabular way to obtain maximum information from a minimum of tests. Dec 21 Circle P 24

Engineering-aptiutde Tests

How good are they? What the tests are like—and some warnings to the unwary. Nov 30 Circle P 23

High-temperature Reinforced Plastics

How they behave under plasma jet oxy-acetylene torch and rocket-engine exhaust. Nov 23 Circle P 22

Mechanical Reliability

Mathematical tools as applicable to bearings, gears and rivets as they are to vacuum tubes or capacitors. Nov 16 Circle P 21

Reinforced-plastic Springs

Leaf springs from epoxy laminates can outperform steel. Nov 9 Circle P 20

continued on page 77

CURRENT REPRINTS.....continued

Latest Trend in Bolt Threads
Root radius is getting larger—75% threads now; 55% threads a possibility. Nov 9 Circle P 19

18 Ways to Control Gear Backlash
This roundup includes latest devices for answering a chronic problem. Oct 26 Circle P 18

Pressure Drops in Pneumatic Systems
New method predicts losses when components are in series. Oct 26 Circle P 17

Yardsticks for Research Success
Equations and procedures used to gage future of a product. Oct 19 Circle P 16

8 Steps to Better Engineering Writing
This eight-part report appeared in serial form from Sep 7 to Oct 26 Circle P 15

3 Steps to a Battery-powered Motor
Electric auto is example—how to choose the best motor for the load. Oct 12 Circle P 14

Closer Look at Cast Iron
For predicting service performance, look at microstructures. Oct 12 Circle P 13

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Replacing gear drive cuts noise and vibration in fast planetary system. Oct 12 Circle P 12

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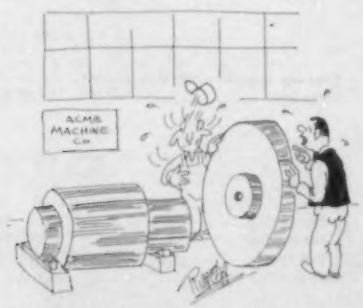

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SPECIAL REPORTS

In the event that you missed some of the Special Reports that appeared in Product Engineering recently, here is a list of those still available. You may obtain any four for $1 by writing Reader Service Dept, PRODUCT ENGINEERING, 330 W 42 St, New York 36. Please enclose remittance with order; we pay postage.

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Special report lists, for the first time, associations of value to the design engineer—where they are, their objectives, membership and standards activity. R 32

Sprayed Reinforced Plastics
Design rules for an ecomonical process that makes large parts from fiberglass-reinforced plastic. R 31

Dimensional Analysis
A ten-step procedure for deriving an expression relating a large number of variables. R 30

Damping Tapes for Vibration Control
Inexpensive, reliable and lightweight way to dissipate excess vibratory energy. Jan 25 R 29

Fiberglass-reinforced Plastic Molded Parts
7 key processes described. Explains their strong and weak points—and shows how one or the other becomes the logical choice in most commercial volume applications. R 28

The NOR-building Block for Logic Circuits
Simple multiple-input electrical relay can be combined with other devices to perform logic functions. R 27

Design of External Shoe Brakes
New equations and coefficients provide a cook-book recipe. R 26

Selecting the Right Electrical Connection (12/7/59)
This special report compares all types—permanent and separate. R 24

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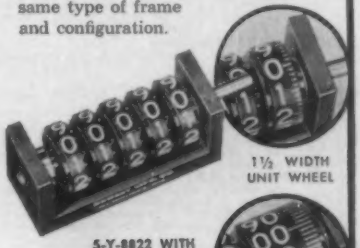
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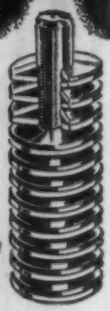

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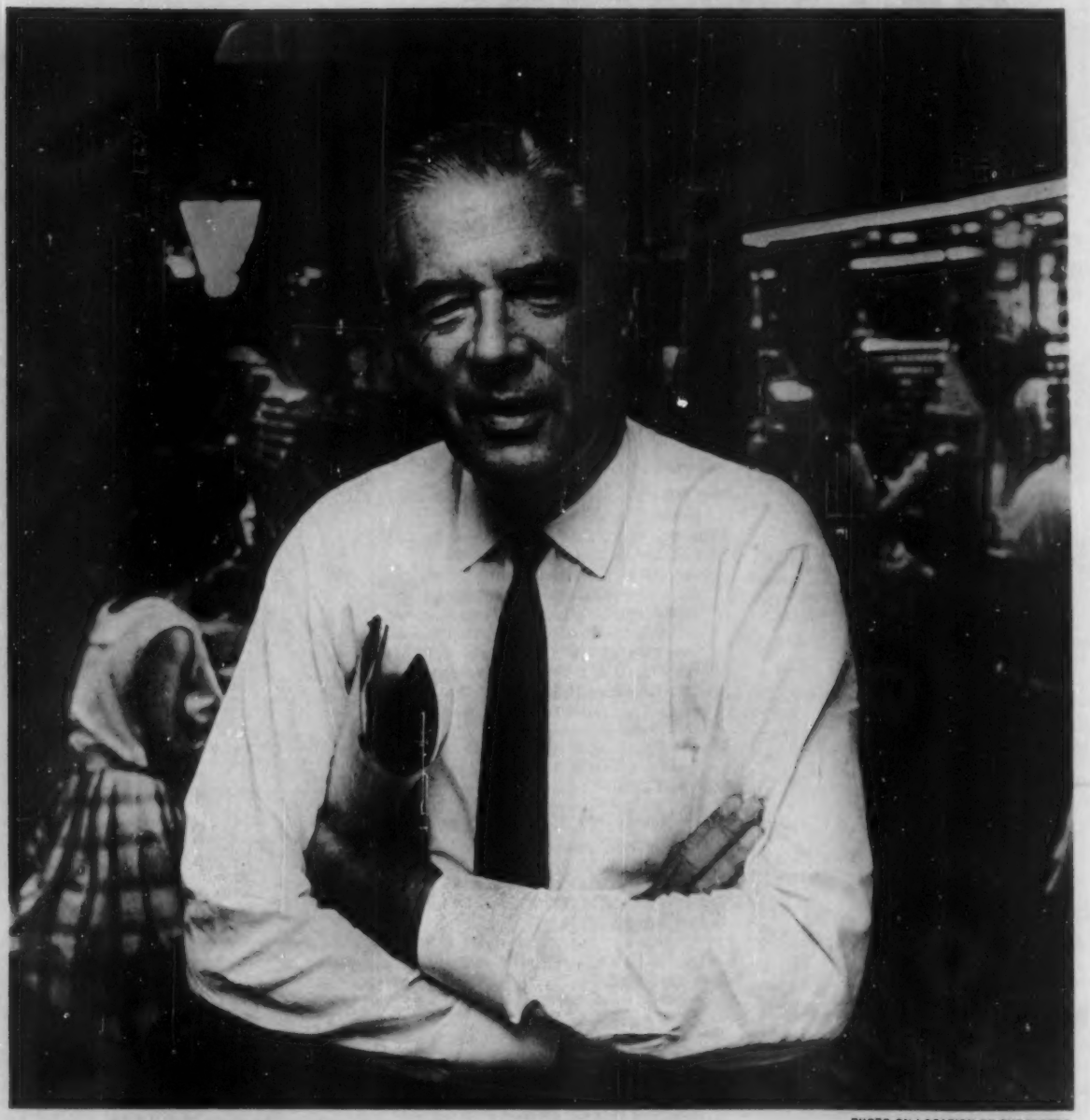

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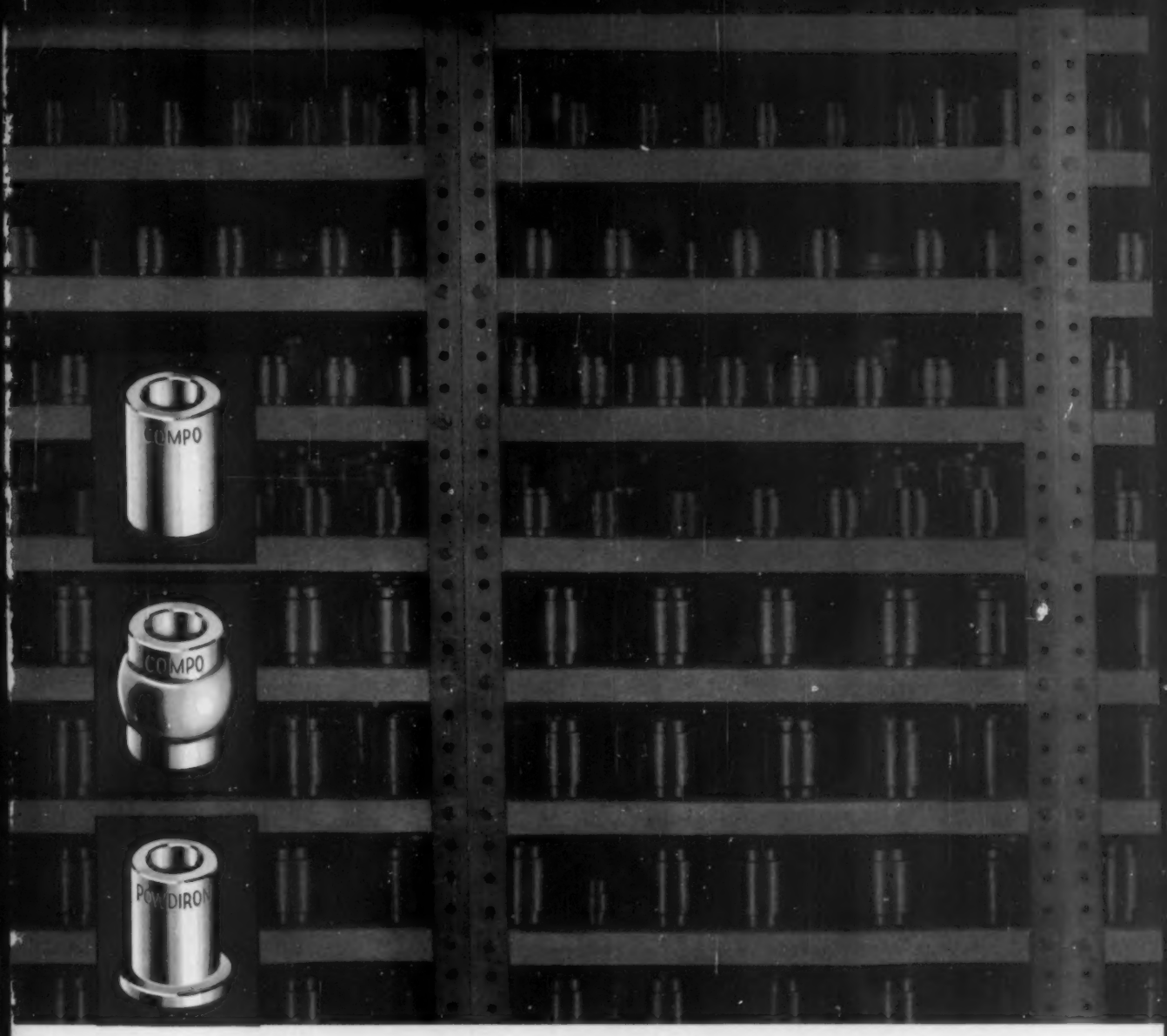

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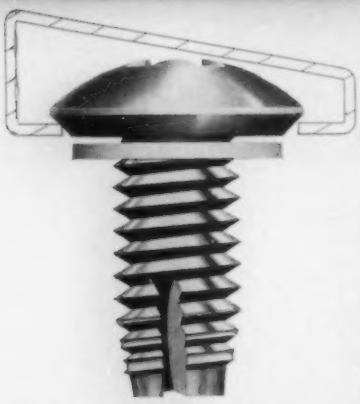

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5¢?–23¢?–57¢?*

*answer: 57¢!

Ideas like this are important to you whether you make refrigerators or not. This one is typical of Shakeproof ingenuity in research and development that daily creates new ideas for industry . . . ideas to improve product performance, to speed assembly operations, to lower total costs. It represents the kind of creative engineering characteristic of Shakeproof designers and engineers who are available to visit your plant, to study your assembly methods and problems and to design ingenious new fastenings for your specific application.

The idea that is saving money for Philco is the Shakeproof® Trim Mounting Thread-Cutting Sems designed so that decorative molding strips can be snapped into place over the fastener. This eliminates a previous three-part fastening operation and the related disadvantages of locating and holding the bolt while the nut is applied from the opposite side. Shakeproof's Trim Mounting Sems cuts its own thread and eliminates the need for a sealant, too, as the nylon washer is drawn down tightly to serve as an effective sealer.

WRITE FOR THIS FREE BOOKLET, *"How to Find Extra Profits in Your Products."*

It gives examples of Shakeproof fastening ideas, how they are being used by leading manufacturers in every industry, and how Shakeproof fastening ideas can work for you.

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DIVISION OF ILLINOIS TOOL WORKS

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Division of Canada Illinois Tools Limited, 67 Scarsdale Road, Don Mills, Ontario

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